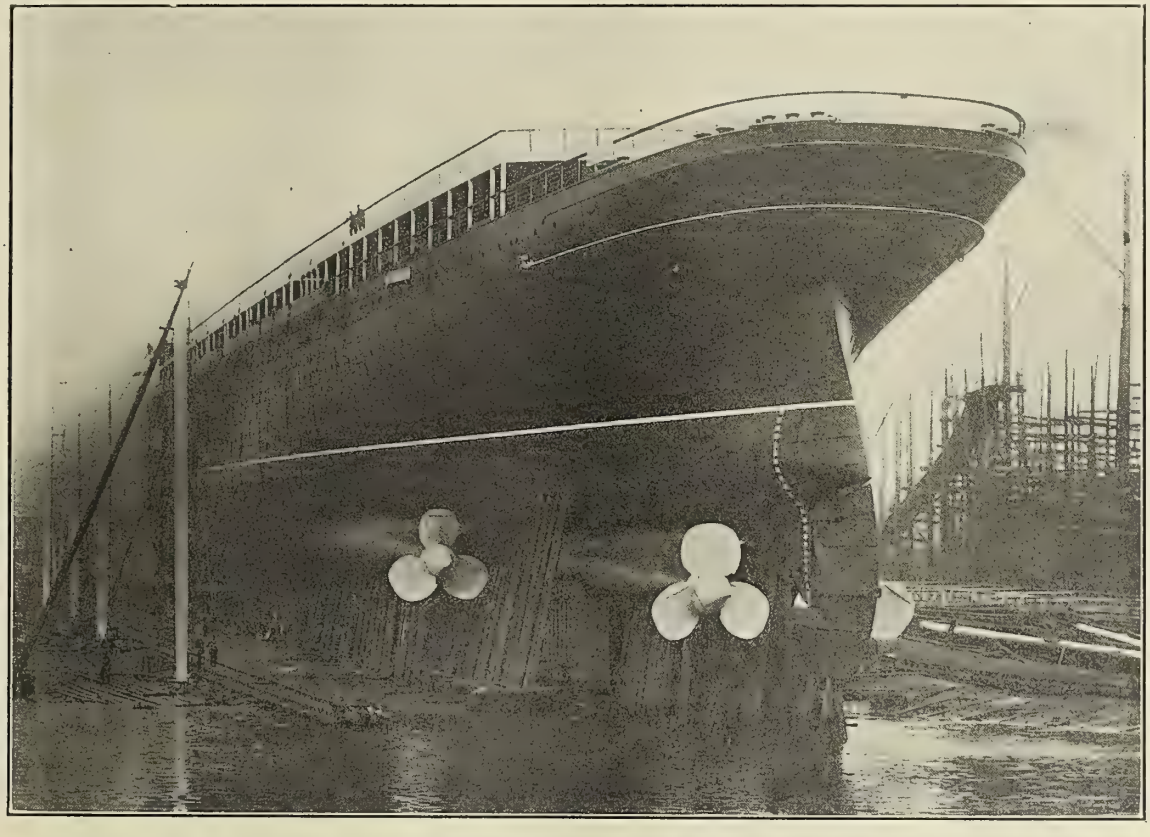
International Marine Engineering

AUGUST, 1906.

THE NEW CUNARD STEAMER LUSITANIA.

Sixty-six years ago the first Cunard steamer crossed the Atlantic. The *Britannia* was a marvel in her time, and boasted the proud strength of 740 horses, which carried her bulk of 1,154 gross tonnage at a speed of 8 knots across the Atlantic. After two-thirds of a century we witness the production of her monster successor, the *Lusitania*, with engines which will drive her 32,500 tons of bulk across the Atlantic at a speed of 25 knots. Just as the *Britannia* was built and engined on the Clyde so is the *Lusitania*. This latest addition to the Cunard fleet and to the Atlantic race of greyhounds has been built by John Brown and Company, Limited, Clydebank, in the yard formerly occupied by J. and G. Thomson and Company.



STERN VIEW OF LUSITANIA, BEFORE LAUNCHING, SHOWING THREE OF THE FOUR TURBINE-DRIVEN PROPELLERS.

The floating of the *Lusitania* on June 7, 1906, marks an epoch in the development of the steamship. She is to steam two knots faster than any previous steamer in the Atlantic service. All shipping men and engineers know the cost of addition to speeds over twenty knots. This addition of two knots has involved an addition of 70 percent to the 40,000 indicated horsepower developed by the present record holders. In the first ten years of steam navigation the speed reached ten knots; in twenty-five years it became thirteen knots. The first Cunarder, in 1840, steamed not over 8½ knots. In 1850 the Cunard addition reached 12.5 knots, doubling the gross tonnage and increasing the power three-fold. In 1862, with the last of the side-wheel Atlantic steamers, the speed was 14.4 knots. The *Gallia* in 1879 was the first of a new series of important ships, in which steam pressures were steadily increased, and the principle of steam expansion in the engine developed, with a relative reduction in weight of machinery. In the fifteen years from 1880 to 1895, a succession of record-breakers contested in speed, which was increased to twenty-two knots, with almost a tripling of the power and an increase of 80 percent to the gross tonnage. The Germans have since raised the speed to twenty-three knots, and the Cunard Company are now raising it to twenty-five knots.

The *Britannia* required only 570 tons of coal to propel her across the Atlantic, while the *Lusitania* will require about 5,000 tons. The *Britannia* burned 5.1 pounds of coal per hour per indicated horsepower for a speed of 8 knots, while the *Lusitania* will burn only 1.45 pounds for a speed of 25 knots.

The *Lusitania* is at present the largest, most powerful and fastest merchant ship afloat. She is unique in having quadruple screws, and has the turbine system in more comprehensive form than any other ship. The outermost screws are about 40 feet forward of the inner pair.

The following are the dimensions of the ship:

Length ..... 785 feet

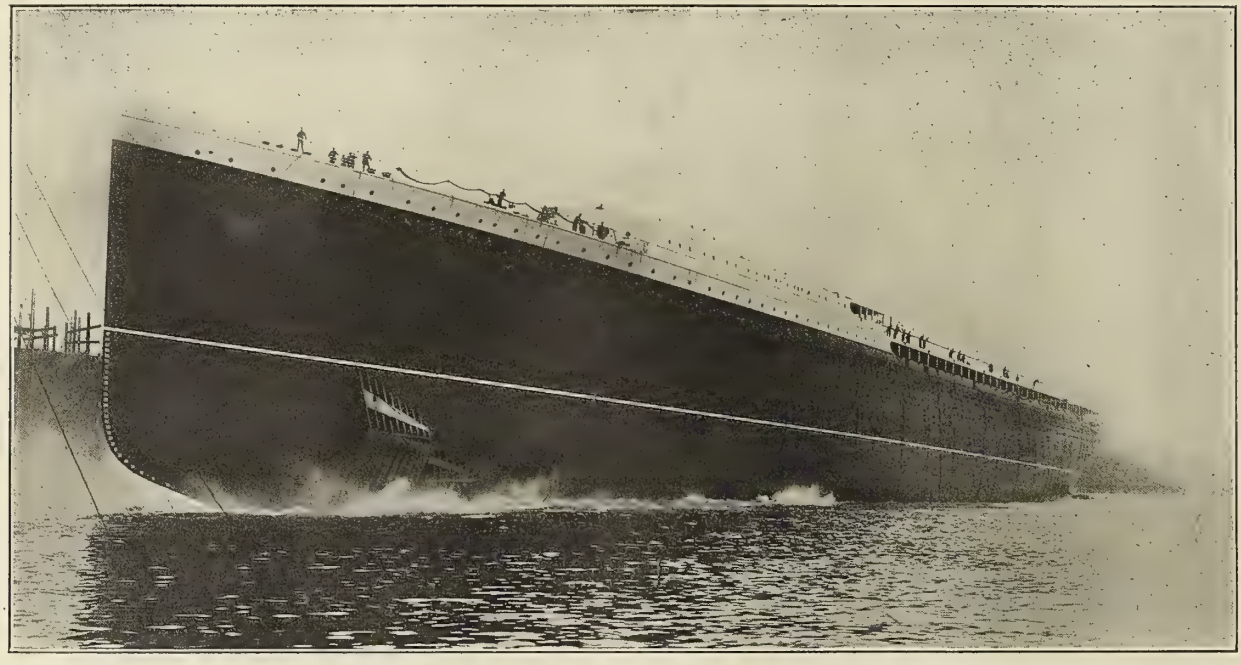
Breadth molded	88 feet
Depth molded	60 feet 6 inches
Gross tonnage	32,500 tons
Load draught	33 feet
Launching weight	16,000 tons

She is 160 feet longer than the *Campania,* and 78 feet 6 inches longer than the *Kaiser Wilhelm II.* The *Great Eastern* was 80 feet shorter, had 5 feet less beam, and 3 feet less depth than the *Lusitania,* which is relatively broader in the beam than her predecessors.

In determining the dimensions and general lines of the ship, John Brown and Company constructed an experimental tank, which is one of the largest tanks yet made. The carriage for the towing of the models and for the recording apparatus is electrically propelled. The carriage tows the model at a speed proportionate to the prospective speed of the proposed ship through a waterway 445 feet long, with a depth varying from 9 to 10 feet, and with a width of 20 feet. The models were 15.8 feet in length, and the speed at which they were towed was 365 feet per minute, equal to about 3⅔ knots. These models were tested over a range of speeds higher and lower than that proportionate to the trial speed of the actual ship, and they were run in three or four conditions of displacement. The apparatus automatically records the resistance in pounds, the distance traversed in multiples of 25 feet, the time in half-seconds, the measure of the current in the water as recorded by the revolutions of two log-screws running in advance of the carriage, and a graphic measure of speed from an instrument used for detecting any want of uniformity of motion. After the trials with the various models, the one which gave the speed required with the minimum resistance, and, therefore, with the minimum of engine-propelling power, was adopted. Further trials were conducted in connection with the four screw propellers which were deemed advisable, owing to the high power to be developed.

The hull is built on the double-bottomed cellular system, the depth between the bottoms being 5 feet. The keel plate consists of three thicknesses of plating, making a total thickness of 3¼ inches, and is 5 feet wide. The double bottom is a complete system of transverse and longitudinal girders riveted entirely by hydraulic power, and extends beyond the turn of the bilge. The framing extends thence to the top of the molded structure (about 55 feet). The plating is chiefly in 40-foot lengths, weighing from 4 to 5 tons. In some cases it has five rows of rivets. Four million rivets are in the structure, and these weigh collectively about 500 tons. The hull is divided by water-tight bulkheads, the doors in which can be closed or opened separately or collectively, by hydraulic power from a central station, or at the door itself, and all operations are under absolute control of the navigating officer. The stem is of forged ingot steel, connected by a steel casting to the center keelson, and the shell plates are rabbeted into it in the usual way. The stern frame and bracket for supporting the propeller shaft are of cast steel. The main pieces weigh nearly 50 tons, and the total is 250 tons, including the rudder. The two brackets for the inner shafts are riveted to the main casting by hydraulic power. The brackets for the outer shafts are connected by large flanges to the main structure of the ship. The rudder is in three pieces, apart from the rudder head of forged steel, which is of 25½ inches diameter. The total weight of the rudder is 65 tons.

The boilers, 25 in number, are cylindrical, most of them of the double ended type, with eight funaces. The total number of

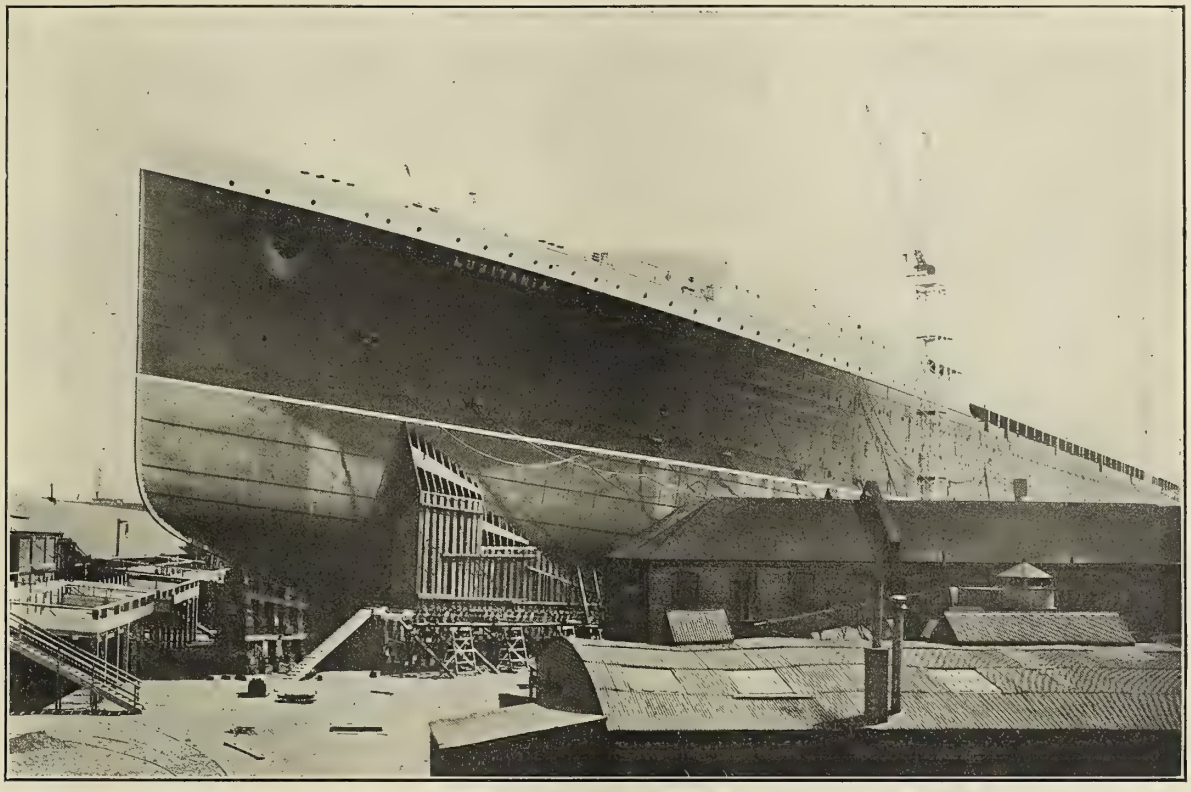


THE NEW CUNARD FLYER ENTERING THE WATERS OF THE CLYDE.

furnaces is 192. These boilers are designed to work under a pressure of 195 pounds per square inch, with the Howden system of forced draught. They are divided into four groups, in four separate stokeholds, and for each stokehold there is an uptake with funnel. The four funnels rise to a height of 154 feet above the keel. Their greatest diameter is 24 feet, and they are oval in shape, so as to reduce the effect of wind pressure. The navigating bridge is 110 feet above the keel, while the masts are 210 feet, or only 56 feet above the tops of the funnels. There are to be two pole masts, to carry the Marconi telegraph gear.

The turbine machinery is very remarkable. There are four shafts, each driving an independent propeller. On the two outer shafts are the high-pressure turbines, taking steam direct from the boilers. After it has passed through these the steam passes to the low-pressure turbines mounted on the inner shafts, and ultimately passes into the condensers. Large turbines for driving the ship astern are on the inner shafts. There are thus six turbines—four for ahead and two for astern motion. The forgings for the shafts and motor drums were made at the works of John Brown and Company at Sheffield. There were also cast the casings which inclose the rotors, with their thousands of blades. These casings are massive pieces of work, the rotor casing and blades of the low-pressure turbines weighing about

450 tons. While the rotor is in one piece the casing requires to be in two pieces, one for the lower part of the circumference and the other for the upper, both being ultimately bolted together to form a complete circle. Around the rotor grooves were turned, into which the actuating blades were secured; and on the inner



BOW VIEW OF NEW CUNARD LINER LUSITANIA ON THE WAYS.

surface of the casing similar grooves were formed for the fixed blades to guide the steam against the moving blades on the rotor. There will be only about one-twentieth part of an inch between the tips of the rotating blades and the surface of the casing, and a similar clearance between the fixed blades on the casing and the surface of the rotor. The speed at the periphery of the circle formed by the blades on the rotor, ranges from 100 to 150 feet per second (68 to 102 miles per hour), so there must be no possible contact between the moving blades and the adjoining surface, yet there must be a minimum space between the blades and the neighboring surfaces, otherwise steam would escape and be wasted.

The blades of the turbines are of brass. Their length increases from the point where the steam from the boiler enters, to the last row, where the steam passes to the condenser. The steam expands continually, and at each row of blades there is a presumed drop in pressure equal to about 1 pound per square inch. Each successive row of blades should be larger than that immediately preceding, but it is found in practice feasible to make five or six rows of the same length. In large turbines such as these, there are nine groups, which successively are of blades of increased length. With fast-running turbines used for driving electric dynamos the blades are very small; but in the *Lusitania,* for the large propellers and running them at low speed, it is necessary to minimize the number of revolutions. Therefore the turbine blades have been fixed at over 20 inches at the low-pressure end of the low-pressure turbine.

The blades of brass were wedged into the grooves formed on the rotor and casing, at right angles to the surface, and in each ring are equi-distant from each other, but to accommodate expansion, the distance between rings increases with their length, so that near the condenser the interval separating the rings attains its greatest width. The blades are bound together by a brass wire tape, which fits into square indents made on the back edge on each blade near the top. This wire is laced with a copper round wire, and the whole is cemented with silver solder. This binding strengthens the long blades. After the blades were put into their grooves in their rotor or casing, and finally secured and bound together, the complete unit was put into a lathe in the case of the rotor, or a boring machine for the casing, to insure that there should not be a greater deviation in length than about the one-thousandth part of an inch, equal length being essential in view of the small clearance between the blades and the surface past which they rotate. The blades are also in perfect alignment, necessitated by the small distance between the edges of the fixed and moving blades. In the larger blades there is a length of edge of quite twenty inches working at a great speed past a corresponding length of fixed blades, and the slightest tendency to rubbing would be disastrous.

A gland packing was devised on a plan to prevent the escape of steam at the end of the turbines, and a system has been perfected for taking up the expansion. The longitudinal adjusting of the rotor within the casing also determines the distance between the edges of the moving and fixed blades. Mr. Parsons devised a system consisting of a "finger plate" secured to the fixed frame of the turbine, which indicates on the rotor shaft the exact clearance permissible, so that the engineer can tell at a glance whether the rotor is in its exact position in relation to the fixed blades in the casing. Screws are provided so that adjustments can be made in the relative position longitudinally of the rotor and casing.

To keep the rotor in a true level in its bearings, and record any tendency to sag, a vertical point is fitted at the end of the casing immediately over the shaft, and by this any change in level of the rotor or shaft, even the thousandth part of an inch, can be detected.

The greater the vacuum the higher the efficiency of the turbine; but as the head of steam and its driving action is opposed to the forward thrust of the propellers, there is not the same

need as with ordinary reciprocating engines for a thrust block to transmit the thrust of the propeller to the ship. In the case of each turbine on the *Lusitania* there is a thrust block for use in starting the machinery, and in changing "ahead" to "astern" motion. In the case of the reversing turbines, the blades are similar to those in the "ahead" turbines, but are mounted with the curve so arranged that the flow of the steam against the concave surface will rotate the shafts and propellers in the stern direction.

The length of ship occupied by machinery, boilers and coal bunkers exceeds 480 feet, and the weight of these items, including water in the boilers, is about 11,000 tons. The total capacity of the bunkers is 6,000 tons of coal, in addition to which provision is made for liquid fuel.

It is too early yet to describe the passenger accommodation and general internal fittings, for these are still *in posse*. But broad features may be named. There are nine decks, including the hold. The upper decks are to be arranged for 550 first-class, 500 second-class and 1,300 third-class passengers. With a crew of about 800, the ship will carry 3,150 souls. The promenading and living spaces for passengers are on a generous scale, the space allowed for each being 50 percent greater than in preceding Atlantic liners. The *Lusitania* will have suites of rooms, single berth cabins, and family suites. The dining arrangements will mark a great advance. In addition to the ordinary dining room there will be a restaurant and a veranda café. The main dining saloon is 125 feet long and 80 feet wide, and seats 500 passengers at once. There will be two passenger elevators, and a complete telephone and electric bell system with a central bureau.

Benjamin Taylor.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of June 11, 1906, the following percentage of completion of vessels building for the United States Navy:

			May 1	June 1
BATTLESHIPS.				
Nebraska	19 knots.	Moran Brothers Co.	92.65	94.
Georgia	19 "	Bath Iron Works	96.58	96.7
Connecticut	18 "	Navy Yard, New York, N. Y.	97.41	97.41
Vermont	18 "	Fore River Shipbuilding Co.	83.8	85.
Kansas	18 "	New York Shipbuilding Co.	78.5	82.2
Minnesota	18 "	Newport News Co.	88.28	89.76
Mississippi	17 "	Wm. Cramp & Sons	54.88	57.67
Idaho	17 "	Wm. Cramp & Sons	53.52	55.73
New Hampshire	18 "	New York Shipbuilding Co.	42.5	45.7
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works	92.8	93.3
South Dakota	22 "	Union Iron Works	90.4	91.1
Tennessee	22 "	Wm. Cramp & Sons	97.51	98.97
Washington	22 "	New York Shipbuilding Co.	97.3	98.2
North Carolina	22 "	Newport News Co.	42.73	46.35
Montana	22 "	Newport News Co.	38.24	41.32
SEMI-ARMORED CRUISERS.				
St. Louis	22 knots.	Neafie & Levy Co.	95.66	96.78
Milwaukee	22 "	Union Iron Works	94.3	95.2
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works	29.44	32.34
Birmingham	24 "	Fore River Shipbuilding Co.	31.3	34.7
Salem	24 "	Fore River Shipbuilding Co.	32.2	35 7
SUBMARINE TORPEDO BOATS.				
Submarine No. 9	.....	Fore River Shipbuilding Co.	68.2	72.5
" " 10	.....	Fore River Shipbuilding Co.	53 5	57.6
" " 11	.....	Fore River Shipbuilding Co.	60.5	64.1
" " 12	.....	Fore River Shipbuilding Co.	53.8	56.9

The Bureau of Navigation reports that there were constructed in the United States during the month of May 149 sail and steam vessels aggregating 49,137 gross tons. Most of these were very small craft, there being only 14 steam-propelled vessels built of steel. The aggregate tonnage of this last number was 41,332, or an average of 2,952 tons. Five of the ships included in this total are over 6,000 tons each.

TRIAL PERFORMANCE OF UNITED STATES CRUISER ST. LOUIS.

BY L. E. BALDT.

The *St. Louis* is a twin screw protected cruiser, and one of the three vessels of this class authorized by an act of Congress approved June 7, 1900. The contract was awarded to the Neafie and Levy Ship and Engine Building Company of Philadelphia, March 11, 1901. The first keel plate was laid July 31, 1902, and the vessel was launched May 6, 1905. The contract price was $2,740,000, of which $1,500,000 was allotted for the hull and $1,240,000 for machinery. The contract price is exclusive of armor, armament, equipment, etc., which were supplied by the government. The contract speed was to be 22 knots; to be maintained for four consecutive hours, on a mean draught of 22 feet 6 inches, corresponding to a displacement of 9,700 tons.

HULL DATA.

Length between perpendiculars (also L.W.L.)	424 ft. 0	in.
Length over all	426 ft. 6	in.
Breadth molded	65 ft. 1¼	in.
" extreme	66 ft. 0	in.
Depth molded to main deck side at M. S.	40 ft. 2	in.
" " " upper deck side at M. S.	47 ft. 7⅝	in.
Draught, normal, mean	22 ft. 6	in.
Displacement, normal (salt water)	9,663.7	tons
" full load (24 ft. 7 in.) salt water	10,776.5	tons
" per inch at L. W. L. (22 ft. 6 in. draught)	44.92	tons
Area of midship section to L. W. L.	1294.4	sq. ft.
" of L. W. L. plane	18,873.	sq. ft.
" wetted surface to L. W. L.	31,838.	sq. ft.
Centre of gravity of L. W. L. plane aft of M.S.	2.14	ft.
" of buoyancy above bottom of keel	12 ft. 10¼	in.
" " " forward of M. S.	1.03	ft.
Transverse metacenter above centre of buoyancy	14 ft. 0 ⅜	in.
Longitudinal " " " " "	509 ft. 8⅝	in.
Coefficient of fineness, block	.53	
" " " of M. S.	.87	
" " " of L. W. L. plane	.67	
" " " cylindrical	.61	
Number of frames	114	
" of watertight compartments	186	

THE UPPER DECK.

The upper deck extends from frame 28 forward to frame 87 aft, and is cut away at the corners to give greater arc of fire to the 6-inch guns forward and aft.

The following boats are carried on the upper deck: one 36-foot steam cutter; one 36-foot launch; one 33-foot steam cutter; one 33-foot launch; two 30-foot cutters; two 30-foot whale boats; one 30-foot gig whale boat; six 26-foot cutters; two 20-foot dinghies; one 14-foot dinghy and two 14-foot punts. Four electrically-operated boat cranes are located on this deck, also four electrically-operated deck winches for coaling and general use.

The forward and flying bridges are forward on this deck, and the after bridge at the after end. On the forward bridge is a chart house fitted for the use of the navigator, and just beneath it on the upper deck is the day cabin for the commanding officer. On the after bridge is the wireless telegraph house. Twelve 3-inch rapid fire guns, two one-pounder, and two automatic .30 calibre guns are on this deck.

THE MAIN DECK.

The main deck is the first of the continuous decks extending the whole length of the ship. Forward on this deck are two electrically-operated deck winches for anchor work, coaling and general uses. Within the superstructure are the berthing space for the crew, hammock nettings, bakery, galleys, executive.

navigator's and paymaster's offices. Aft, outside of the superstructure, is located one electrically-operated winch for general service. There are six 6-inch and six 3-inch guns on the main deck.

GUN DECK.

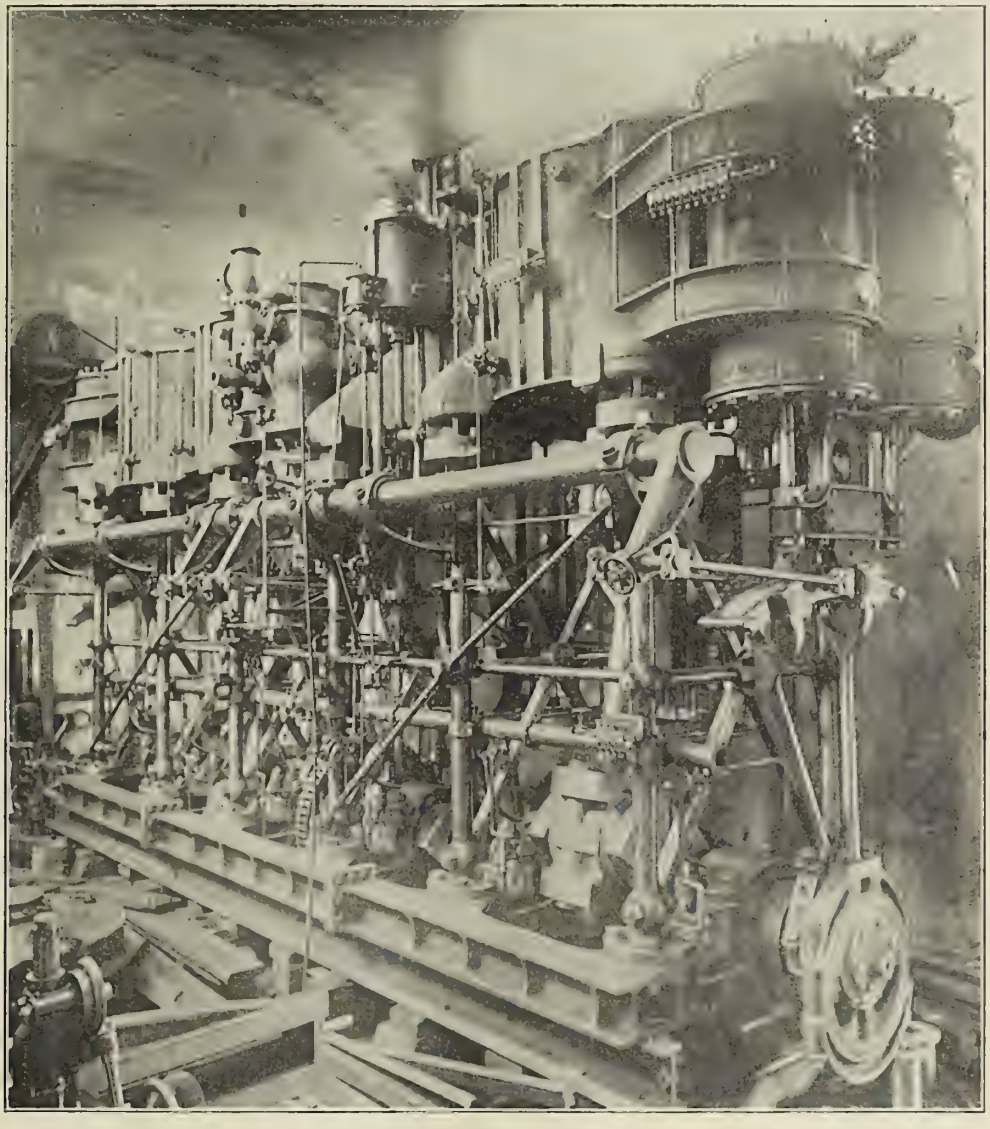
Forward of the casemate, on this deck, are the crew's showers, water closets and berthing space and laundry. Aft of the casemate are the armory, officers' lavoratories, wardroom officers' rooms and mess room, captain's office, pantry and cabins. On this deck there are eight 6-inch guns, twelve 3-inch guns and two 1-pounder rapid-fire guns.

BATTERY.

The main battery consists of fourteen 6-inch rapid-fire rifles, 50 calibres in length. The secondary battery consists of eighteen 3-inch rapid-fire guns, 50 calibres in length; twelve 3-pounder semi-automatic guns, four 1-pounder heavy automatic guns; two machine guns, .30-calibre, and eight automatic guns, .30-calibre.

EQUIPMENT.

Electric Plant.—There are two 100-kilowatt, and three 50-kilowatt generating sets of 125 volts pressure at the terminals, furnished by the Sturtevant Company. The engines are of the vertical



PORT ENGINE OF CRUISER SAINT LOUIS, ERECTED IN SHOP.

THE BERTH DECK.

Forward on this deck are paints and oils, prisons, band room, isolated ward, sick-bay, dispensary, crew's berthing space, chief machinist's and chief petty officers' quarters and lavatories, blacksmith shop, firemen's and servants' wash rooms. Aft are junior and warrant officers' staterooms and mess rooms and wardroom state rooms. The evaporator room, ice machine and refrigerating rooms, and store rooms are located on this deck.

The protective deck extends the whole length of the vessel, and its level corresponds with that of the berth deck. The upper platforms are below the protective deck, and are arranged for stores, magazines, ammunition passages, upper dynamo room, steering gear, etc. The lower platforms are below the upper platforms, and arranged for stores, magazines, etc.

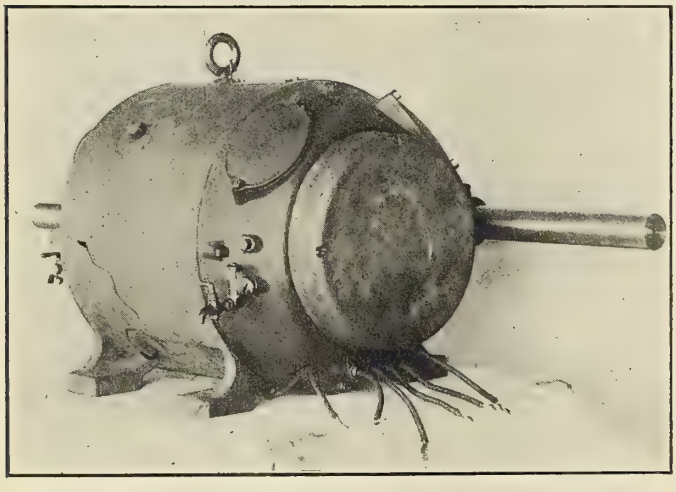
cross-compound type, and for the 50-kilowatt sets have cylinders 7½ and 14 inches in diameter by 8 inches stroke. For the 100-kilowatt sets the cylinders are 9½ and 18 inches in diameter by 10 inches stroke. The dynamos are of the direct current compound wound multipolar type, and the wiring is arranged on the two-wire feed system. There are about 1000 incandescent lamps, 12 inclosed arc lamps, six 30-inch search lights, two electric night signalling sets, two truck lights and two diving lanterns with 150-candle power lamps, 46 desk and bracket ventilating fans.

Anchor Windlass.—A Hyde anchor windlass is located forward in a pocket between the main and gun decks. The windlass engine is on the gun deck just forward of the windlass pocket, and is a two-cylinder, vertical, inverted, reversible engine, having two 15-inch cylinders of 14-inch stroke.

Steering Engine.—A Hyde combined steam and hand steering engine is located on the upper platform deck, aft of bulkhead on frame 102. The engine is two-cylinder, horizontal, direct acting, with two 16-inch cylinders of 12-inch stroke. Steering stations are located on flying bridge, pilot house, conning tower, communication room on upper platform deck forward, steering gear room, and steering room on upper platform deck aft.

Winches.—There are seven 25-horsepower electrically driven deck winches, four of which are located on the upper deck, two forward on the main deck and one aft on the main deck.

Ammunition Hoists.—There are 27 electrically operated ammunition hoists fitted to furnish ammunition to the battery. The motors are reversible and operate at about 1000 R. P. M. Frictional slip gears are provided between the motors and the hoists to prevent damage being done in case of sudden stoppage of the hoists. Stops are fitted to prevent ammunition from falling back in the hoists.

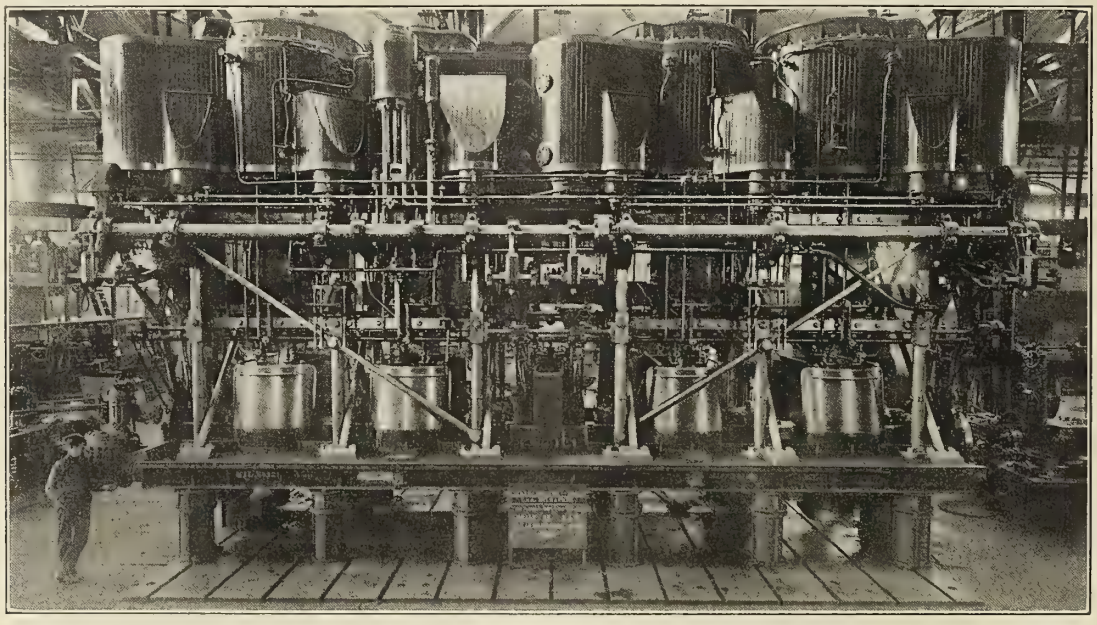


STURTEVANT MOTOR FOR AMMUNITION HOIST.

Ground Tackle.—The following anchors are supplied: two bower anchors, National patent type; one sheet anchor, Navy type; one stern anchor, Navy type; one stream anchor, Navy type; two kedge anchors, Navy type; eighteen boat anchors, two buoy anchors.

PROPELLING MACHINERY.

There are two main engines placed abreast, in separate watertight compartments, with a communicating door in the centerline bulkhead between the two engine rooms. The engines are of the four-cylinder, vertical, inverted, direct-acting, triple-expansion type, and designed to indicate 21,000 horsepower at about 133 revolutions per minute, with a steam pressure of 250 pounds at the high-pressure cylinder, and arranged for inboard turning screws. The order of the cylinders, beginning forward, is: forward L. P., H. P., I. P., and after L. P. The forward L. P. and H. P. cylinders are rigidly bolted together, also the I. P. and after L. P. cylinders. Facings, however, are left on the after side of high-pressure cylinders fitting removable guides on intermediate cylinder casings, to prevent side motion, and at the same time to allow for expansion in a fore and aft direction.



ENGINE OF THE CRUISER MILWAUKEE, SISTER TO THE ST. LOUIS.

(Photograph, 1905, H. W. Jumper)

All cylinders are of cast iron and are steam jacketed around the working liners. The heads of the intermediate and low-pressure cylinders are also jacketed.

The cylinders, for each engine, are supported by twelve forged-steel columns, flanged at top and bottom, for bolting to cylinders and bed plates. For each athwartship pair of columns there are two diagonal braces, rectangular in section, forming an X-brace. The outer ends are tongued and fitted to grooves at top and foot of columns and bolted. The two braces are secured together at their centers by two keys, also by a horizontal athwartship tie-rod passing through columns and braces, with sleeve distance pieces. The framing is further stiffened by fore and aft horizontal and diagonal tie rods secured to columns. There are two cast steel strong backs bolted to outboard row of columns, to which the crosshead guides are bolted.

The athwartship tie rods that are usually fitted between the main engine cylinders of opposite engines on naval vessels of this size were omitted, and it was found after trial they were not necessary, for the vibration of engines at all speeds was not excessive.

The bed plates are steel castings, each in three sections, and securely bolted together. Each section has two longitudinal girders and two cross girders, all of I section, stiffened by ribs, and finished for crank-shaft bearings, columns and turning engine. The bed plates are bolted to the engine keelsons by body-bound bolts, with steel washers fitted at each holding-down bolt between bed plate and engine keelson. Yellow pine strips are fitted between the washers.

The high-pressure steam pistons are made of cast iron, the intermediate and low-pressure pistons of cast steel, conical in shape, and finished all over. Wrought steel followers hold in place hard cast iron packing rings, one wide ring being fitted in each high and intermediate pressure piston, and two narrow rings in the low-pressure pistons. The piston rods are made of forged nickel-steel, oil-tempered and annealed, with bored axial holes the entire length. The rods are accurately ground and polished to an outside diameter of 8 inches.

The crossheads are made of forged steel. The pins extend on each side of the crosshead and are forged in one piece with it. The slippers are cast steel, bolted to the outboard side of the crosshead, and the sliding surfaces are faced with navy standard white metal.

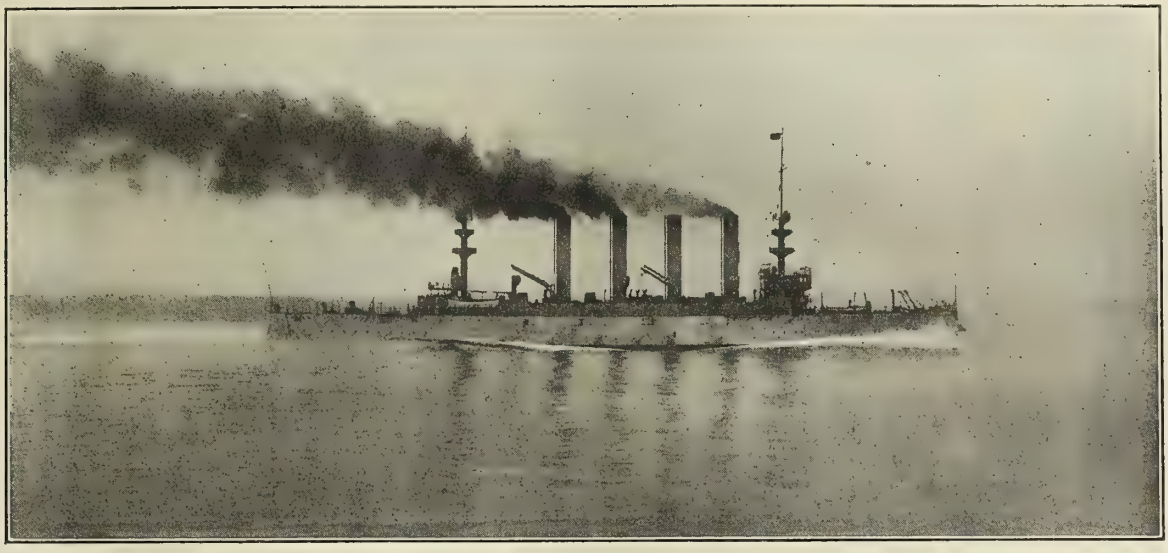
Cast iron crosshead guides, made hollow for the circulation of cooling water, are bolted to the cast steel strong backs on the back engine columns, and at their tops to the cylinder casings. The backing guides are also made of cast iron, and bolted to flanges on the go-ahead guides.

The connecting rods are of forged nickel-steel, oil-tempered and annealed, with axial holes the entire length. The upper ends are forked to span the crossheads, and carry the crosshead pin brasses. Both the crosshead and crank-pin brasses are lined with navy standard white metal.

The valve chest of each high-pressure cylinder is fitted with one, and the intermediate and low-pressure cylinders with two, single-ported piston valves. The valves are cast iron, made hollow for the passage of steam to the ends of the valve chest, and are all provided with balance pistons, the cylinders of which form part of the upper covers of the valve chests. Each end of the piston valves is fitted with a single cast-iron packing ring, held in place by a forged steel follower, and made to permit of contraction but not expansion. The piston valves for all cylinders are operated by the Stephenson double-bar link motion with adjustable cut-off.

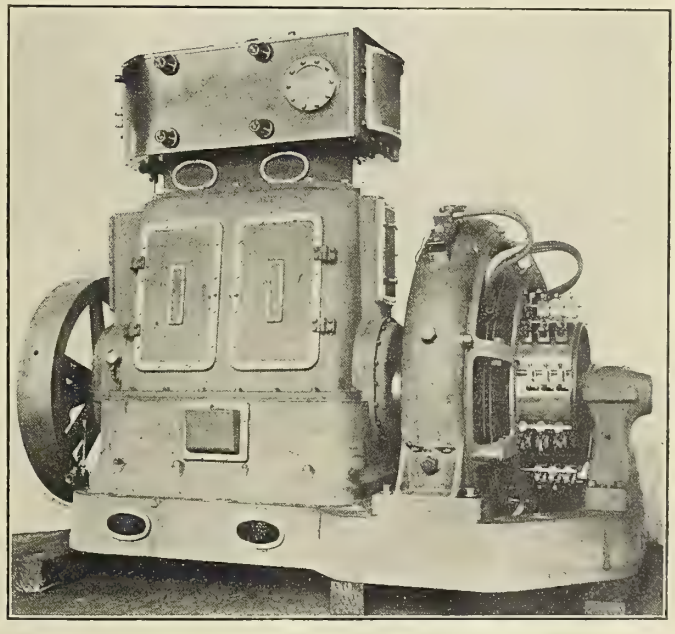
The eccentrics are made in two parts, the larger part being made of cast iron, the smaller of forged steel, and secured together by 2-inch steel bolts. Each backing eccentric is rigidly keyed to the crank shaft, and the go-ahead eccentric is secured to the shaft by a key, with adjusting pieces between the key and eccentric. The eccentric straps are composition, lined with white metal. The eccentric rods are nickel-steel with forked upper ends to span the links, and T-heads at lower end for bolting to eccentric straps. The main links are nickel-steel, double-bar, with pins forged on for drag links and eccentric rods. The link blocks are also nickel-steel, and are fitted with adjustable composition gibs.

There is a 14-inch balanced throttle valve fitted on each engine, balanced by piston working in a cylinder forming a part of the throttle-valve casing, steam being admitted to the back of the balance piston. To further insure ease in closing, a toggle gear is fitted to valve stem.



UNITED STATES ARMORED CRUISER SAINT LOUIS ON OFFICIAL TRIAL TRIP.
(Copyright, 1906, N. L. Stebbins, Boston.)

The crank, line, thrust, propeller and stern-tube shafts are forged nickel-steel with axial holes their entire length. The crank shafts for each engine are made in two sections, with two cranks on each section, placed opposite each other. The forward low-pressure and high-pressure cranks are opposite; also the intermediate-pressure and after low-pressure cranks; the second pair being at right angles with the first, and the sequence of the cranks being high, intermediate, forward low-pressure, and after low-pressure. Each complete crank shaft has six main bearings, each thrust shaft two steady bearings, and each line shaft one steady bearing. Each stern-tube shaft is supported by bearings



ONE OF THE ELECTRIC GENERATING SETS.

at each end of stern-tube, and each propeller shaft has one strut bearing. The stern-tube and strut bearings are lined with lignum-vitæ, end grain exposed, while the main and steady bearings are lined with white metal.

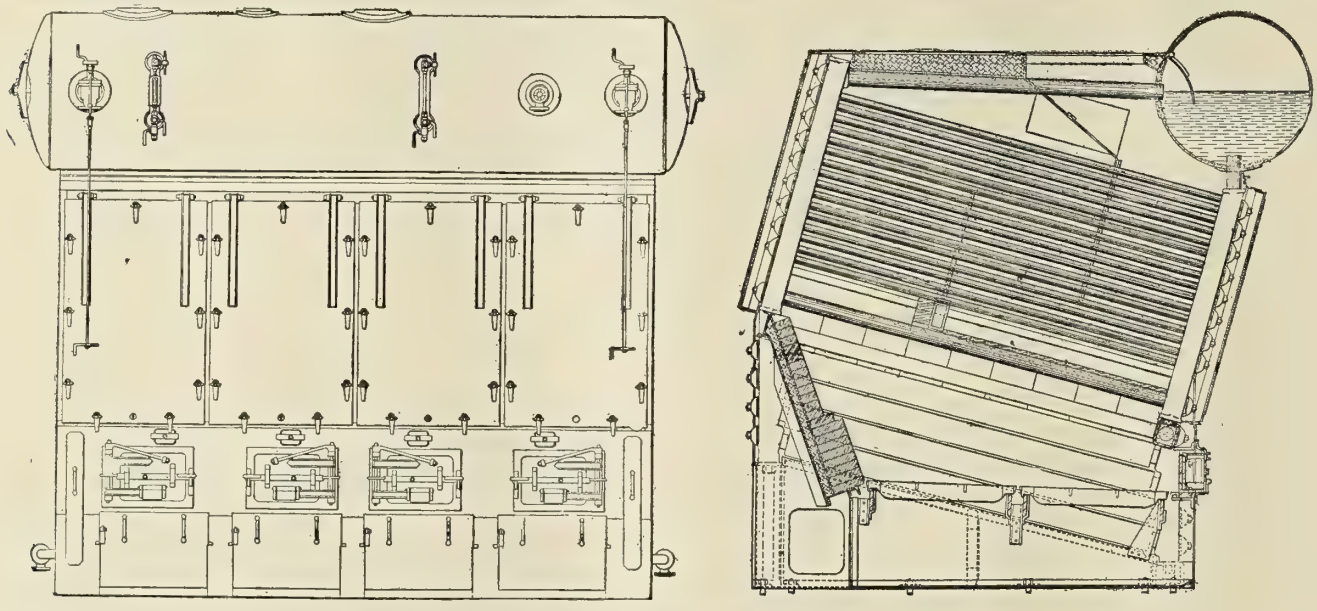
The thrust bearing is of the horseshoe type. The body is of cast iron, and the horseshoes cast steel. The end and side walls of the body form an oil reservoir, in which the lower part of the collars turn. The reservoir is fitted with a circulating coil for cooling water. The horseshoes are made hollow for the circulation of cooling water, and faced with white metal.

The outboard coupling connecting stern-tube and propeller shafts consists of a forged steel sleeve, bored taper for ends of shafts, and secured by longitudinal and cross keys. The coupling connecting the stern-tube and line shafts consists of a collar securely keyed to forward end of stern tube shaft by four keys. Aft of this collar another collar of the same diameter, made in halves, is secured to the forward collar and to the after coupling flange of the line shafts by eight 3 9/16-inch fitted bolts.

The turning engine is a double-cylinder, inverted engine, secured to the outboard side of the main engine bed plates and connected by worm gearing to the crank shaft. The cylinders are 6 inches in diameter and 6 inches stroke. A ratchet is fitted for hand turning.

The maneuvering of the main engines is controlled by a vertical steam reversing engine, bolted to the front of each engine, of the floating lever type, and with an oil-controlling cylinder. The reversing shaft is carried in bearing brackets bolted to front engine columns. The shaft is provided with an arm for each link, with independent adjustable cut-off blocks.

A complete oil and water system is provided, extending to all parts of the main engines.



LAYOUT OF ONE OF THE BABCOCK AND WILCOX WATER TUBE BOILERS.

MAIN ENGINE DATA.

Cylinders; high-pressure, diameter, inches	36
intermediate-pressure, diameter, inches	59½
low-pressure (2), diameter, inches	69
Stroke of all pistons, inches	45
Piston valves, high-pressure, diameter, inches	22
intermediate-pressure, diameter, inches	25½
low-pressure, diameter, inches	25½
Cylinder ratios 1 : 2.73 : 7.34	
Main steam pipe, diameter at throttle, inches	14
Exhaust pipe to condenser, diameter, inches	27
Piston rods, diameter, inches	8
axial hole, H. P., diameter, inches	1½
I. P., diameter, inches	4
F. L. P., diameter, inches	5
A. L. P., diameter, inches	4
Connecting rods, length center to center, inches	90
diameter, upper end, inches	8⅛
diameter, lower end, inches	9⅜
axial hole, H. P., diameter, inches	1½
I. P., diameter, inches	3
L. P., diameter, inches	5
Crank shafts, diameter, inches	18
axial hole, diameter, inches	11½
coupling flange, diameter, inches	32
coupling flange, thickness, inches	3¾
coupling bolts (8) diameter, inches	3 9/16
journals, diameter, inches	18
(2) lengths, inches	32¾
(2) lengths, inches	22½
(1) length, inches	31
(1) length, inches	27¾
length over all, feet and inches	35-3
Crank pins, diameter, inches	18½
length, inches	22
diameter of axial hole, inches	12
webs, width, inches	20
thickness, inches	17¼
Crosshead pins, diameter, inches	10¼
length (each side of crosshead), inches	10¾
axial hole, H. P., diameter, inches	1½
I. P. and L. P., taper, diameter, inches	6 to 2
Crossheads, wearing surface, ahead, square inches	732
backing, square inches	274.5
Thrust shaft, diameter, inches	17¼
axial hole, diameter, inches	11½
collars, number, each shaft	13
diameter, inches	25¼
thickness, inches	2
space between, inches	4
length, feet and inches	12-6
Line shaft, diameter, inches	17
axial hole, inches	11½
length, feet	22
coupling flange, diameter, inches	32
thickness, inches	3¾
bolts (8), diameter, inches	3 9/16
Stern tube shaft, diameter, inches	18
axial hole, diameter, inches	11
length, feet and inches	32-8⅜

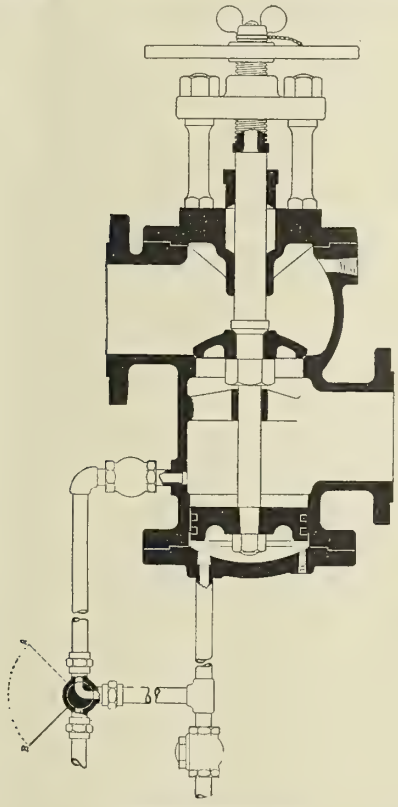
Propeller shaft, diameter, inches	18
axial hole, diameter, inches	11
length, feet and inches	36-5

BOILERS.

There are sixteen Babcock and Wilcox water tube boilers, placed in four water-tight compartments, and designed for a working pressure of 265 pounds per square inch.

Steam drum, inside diameter	42 ins.
thickness	21/32 ins.
Grate, length	7 ft. 0 ins.
width	12 ft. 6 ins.
surface, one boiler	87.5 square feet.
all boilers	1,400 square feet.
Heating surface, one boiler	4,000 square feet.
all boilers	64,000 square feet.
Ratio of grate surface to heating surface	45.71
Elements, one boiler (21 intermediates, 2 sides)	23
Tubes, one boiler, 2-inch, No. 8 B. W. G., 9 ft. 2 ins. long.	722
4-inch, No. 6, B. W. G., 9 ft. 2 ins. long..	23
4-inch, No. 6, B. W. G., 7 ft. 3 ins. long..	23
Safety valves (1 triple-type each boiler), total	48
diameter of each valve	3 ins.
Smoke pipes (4), diameter, inside	8 ft. 0 ins.
cross sectional area, each	50.265 sq. ft.
total	201.06 sq. ft.
height above grates	92 ft. 6 ins.

Boiler Stop Valves.—The boiler stop valves are the invention of Commander A. B. Willitts, United States Navy. These valves are steam opening as well as steam closing. Heretofore, steam

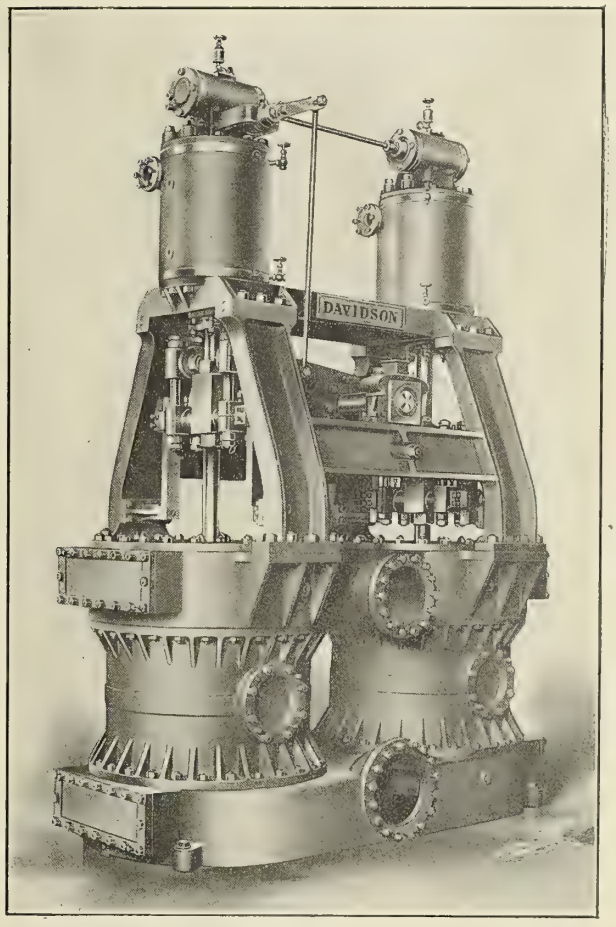


WILLITTS STOP VALVE.

closing valves have been designed with a steam cylinder separate from the valve chamber, and in which steam was used for closing the valve only. Two stuffing boxes were necessary, and the keeping of these tight was an added difficulty. The Willitts valve carries the valve and actuating piston in the same chamber. The two-way operating cock shown in cut, for steam opening and closing of these valves, is located in the next compartment aft the one containing said set, each boiler having its own separate and independent cock. These valves have worked satisfactorily in all respects.

Mode of Operation.—As a hand-operated valve its functions are obvious and need no extended description.

As a steam opening and closing stop or throttle valve the hand nut on the end of the valve stem is unscrewed entirely from the threaded end (as it always is when the valve is in service), but is left attached by a chain, to prevent its becoming lost or mislaid; the screw sleeve is backed from the valve stem shoulder, by means of the hand wheel, sufficiently to permit the valve disk to raise to its "full open" position. Then, to open the valve, the lever of the two-way cock is slowly moved, so as to admit steam from the valve chamber into the chamber at outer end of piston and balance the unit pressure on both sides of the piston. The greater force from the total pressure on the piston being on the outside (owing to the area of the stem), this dif-



ONE OF THE MAIN AIR PUMPS ON THE ST. LOUIS.

ference, together with the pressure on the under side of the valve disk, unseats the latter and opens the valve.

To close the valve the lever of the two-way cock is moved to a position which closes the communication between the two chambers and opens the chamber at the outer end of the piston to the atmosphere and releases the pressure on the outside of the piston. The area of this piston on the valve side, being greater than the area of the valve disk, causes the piston to move outward and bring the valve disk to its seat and thus close the valve. It is obvious that the rapidity with which the lever of the two-way cock is moved determines the rapidity of motion of the valve disk. The connections of the pipes are preferably so made that the chamber at the outer end of the piston becomes filled with water of condensation, the inflow and outflow of which will control more rigidly the movement of the piston, and also hold the valve disk from chattering on its seat when but little steam is flowing through the valve.

DATA FROM STANDARDIZATION RUNS OF U. S. S. ST. LOUIS ON MEASURED MILE OFF ROCKLAND, MAINE, MAY 16, 1906.

Number and Direction of Run	Time on Course Min.	Time on Course Sec.	Which Engine	Revs. of Main Engines To Make One Knot	Revs. of Main Engines Per Minute	Revs. of Main Engines Average	Speed in Knots	Indicated Horsepower Main Engines H. P. Cyl.	I. P. Cyl.	F. L. P. Cyl.	A. L. P. Cyl.	Total	Total Both Engines	Auxiliaries in Operation	Total All Machinery	Steam Pressures Gauge In Boilers	Steam Pressures Gauge At Engs.	Steam Pressures Absolute H. P. St'm Chest	Steam Pressures Absolute 1st Rec'r	Steam Pressures Absolute 2nd Rec'r	Mean Effective Pressure H. P. Cyl.	Mean Effective Pressure I. P. Cyl.	Mean Effective Pressure F. L. P. Cyl.	Mean Effective Pressure A. L. P. Cyl.	Mean Effective Pressure Referred to I. P. Cyls.	Vacuum in Inches	Air Pressure in Inches of Water	Cut-off in Cylinders H. P.	Cut-off in Cylinders I. P.	Cut-off in Cylinders F. L. P.	Cut-off in Cylinders A. L. P.
1-N	2	41.9	S	410.65	152.43	151.4	22.236	4023.8	3818.1	2830.6	2805.0	13477.5	27017.0	368.4	27385.4	269	255	260	110	43	117	40	22	21.8	52.38	27	1.50	Full Gear	Full Gear	Full Gear	Full Gear
			P	407.45	151.24			4026.5	3883.0	2868.6	2821.4	13539.5					260	265	112	43	118	41	22	22.1	53.03	27.5					
2-S	2	43.05	S	410.20	150.90	150.43	22.079	4017.5	3638.1	2776.8	2802.2	13234.6	26864.6	449.2	27313.8	271	245	250	103	41	118	38.5	21.8	22	51.95	27.5	1.56				
			P	407.60	149.95			4126.1	4037.7	2784.6	2784.6	13630.0					250	253	110	42	119	43	22	22	53.85	27.5					
3-N	2	45.75	S	409.30	148.57	147.79	21.719	3787.8	3535.3	2721.4	2784.0	12828.5	25418.4	485 9	25904.3	261	240	240	105	42	113	38	21.7	22.2	51.15	27.5	1.60				
			P	405.00	147.01			3582.2	3820.5	2630.8	2556.4	12589.9					240	240	105	40	108	41.5	21.2	20.6	50.72	27.5					
4-S	2	40.55	S	408.50	152 81	152.17	22.423	3889.0	3827.6	2876.4	3057.0	13650.0	27502.8	475.4	27978.2	275	250	255	105	45	112.8	40	22.3	23.7	52.91	27	1.52				
			P	405.05	151.52			3931.5	4127.5	2941 7	2852.1	13852.8					255	260	115	45	115	43.5	23	22.3	54 16	27.5					
5-N	2	41.40	S	412.25	153.25	152.66	22.305	4026.9	3933.4	2974.3	3155.3	14089.9	28085.4	473.0	28558.4	277	250	255	110	45	116.5	41	23	24.4	54.48	27	1.68				
			P	409.05	152.06			4048.0	4094.5	3054.9	2798 1	13995.5					255	260	110	44	118	43	23.8	21.8	54 52	27.5					
6-S	2	45.20	S	402.60	146 40	146 17	21.792	3468.2	3346.1	2496.3	2644 5	11955.1	24216.4	462.6	24679.0	276	250	250	100	40	95	36.5	20.2	21.4	48.37	27	1.50				
			P	401.30	145 93			3457.2	3692.0	2623 8	2488.3	12261.3					240	260	100	39	105	40.4	21.3	20.2	49.77	27.5					
7-N	2	58.15	S	409.70	137.87	136 53	20.208	3141.7	2823.2	1978.4	2187.9	10131 2	19426.8	381 6	19808.4	274	220	220	80	35	101	32.7	17	18.8	43.53	27	1.00				
			P	401.70	135.18			2897.5	2666.6	1905.7	1825.8	9295.6					195	265	77	30	95	31.5	16.7	16	40.73	27.5					
8-S	2	53.6	S	401.05	138.61	136.95	20.737	3002.2	2864.3	2106.0	2199.6	10172.1	19266.8	351.0	19617.8	260	250	250	80	35	96	33	18	18.8	43.47	27.5	.80				
			P	391.40	135.28			2777.5	2651.6	1884.2	1781.4	9094.7					255	260	78	30	91	31.3	16.5	15.6	39 82	27.5					
9-N	3	2.55	S	401.05	131.89	132.37	19.721	2559.1	2229.9	1658 8	1736.7	8184.5	17348.2	318.9	17567.1	276	260	260	66	29	86	27	14.9	15.6	36.76	27.5	.80				
			P	403.95	132.84			2847.3	2661.9	1827.7	1726.8	9063.7					260	267	79	30	95	32	16.3	15.4	40.42	27.5					
10-S	3	1.50	S	389.40	128.07	127.65	19 835	2485.0	1972.9	1416.2	1545.9	7420.0	15009.5	335 1	15344.6	261	250	250	60	26	86	24.6	13.1	14.3	34.31	27.5	.60				
			P	384.85	127.23			2353.9	2207.0	1535.8	1492 8	7589.5					255	260	68	26	82	27.7	14.3	13.9	35.33	27.5					
11-N	3	10.40	S	392.90	123.81	124.06	18.908	2151.0	1705.7	1264.6	1379.5	6500.8	13407.9	311.2	13719.1	273	260	155	55	24	77	22	12.1	13.2	31.10	27.5	.35				
			P	394.45	124.31			2285.9	2008.4	1332.6	1280.2	6907.1					265	265	167	63	24	81.5	25.8	12.7	12.2	32.91	27.5					
12-S	3	9.95	S	380.75	120 40	120.43	18.952	1874.4	1583.3	1138.3	1158.6	5754.6	11868.5	297.1	12165.6	278	265	144	50	21	69	21	11.2	11.4	28.31	27.5	.40				
			P	380.95	120.46			2106.4	1750 1	1138.9	1118.5	6113.9					275	155	55	21	77.5	23.2	11.2	11	30.07	27.5					
13-N	3	24.05	S	393.55	115.73	115.46	17.643	1644.9	1340.7	976.9	1025 7	4988.2	10185.6	291.5	10477.1	267	260	130	45	19	63	18.5	10	10.5	25.53	27.5	.35				
			P	391.70	115.18			1884.1	1514.7	804.4	904.2	5197.4					265	139	47	19	72.5	21	9.2	9.3	26.73	27.5					
14-S	3	27.4	S	386.85	110.18	109.84	17.358	1342.4	1110.8	874.2	883.5	4210.9	8499 1	270 5	8769.6	264	255	255	115	40	54	16.1	9.4	9.5	22.64	27.5					
			P	378.50	109.50			1457.6	1268.5	785.7	776.4	4288.2					260	122	41	17	59	18.5	8.5	8.4	23.20	27.5					

AUXILIARY MACHINERY.

Main Condensers.—There is one main condenser located on the outboard side of each engine room. The shell plating is steel boiler plate, the heads composition, tube sheets of rolled Muntz metal, and tubes seamless drawn and of a mixture 70 copper, 29 zinc, 1 tin. The forward head, being the one for the entrance and exit of circulating water, has a division plate fitted with valves which, when open, allow the circulating water to pass overboard direct when pumping from the bilge. These valves are operated by a lever on the outside of the condenser. Baffle plates are fitted to direct the steam over all the tubes. The ratio of total cooling surface to total heating surface is 1 to 2.38.

Diameter of shell, inside	7 ft. 0 ins.
Thickness of shell	⅜ inch.
Tubes, diameter, outside	⅝ inch.
thickness, No. 18 B. W. G.	0.049 inch.
length between tube sheets	14 ft. 4 ins.
number in each condenser	5,714
Cooling surface, square feet, each	13,400
square feet, total	26,800

Main Air Pumps.—There is one double, vertical-beam, single-acting Davidson air pump, with two inverted steam cylinders, for each main engine. Each air-pump bucket contains 18 5-inch valves built up of three flat disks of rolled manganese bronze plates 1/32-inch thick. The suction and discharge valve decks each contains 20 similar valves.

Diameter of steam cylinders, each	14 ins.
water cylinders, each	33½ ins.
Stroke	18 ins.
Diameter suction nozzle	12½ ins.
discharge nozzle	10 ins.

Main Circulating Pumps.—To furnish cooling water for each main condenser there is one double-inlet, centrifugal, circulating pump, driven by a vertical, compound engine with cranks at right angles. Each pump is fitted to draw from the sea, the main drain, and the engine-room bilge. These three suction valves are interlocked in such a way that only one can be opened at a time. Each of these pumps is capable of discharging 12,000 gallons per minute from the bilge.

Diameter of steam cylinders	10 and 18 ins.
Stroke	9 ins.
Diameter of pump runner	48 ins.
Width of runner at periphery	5¾ ins.
Diameter of inlet nozzle	20½ ins.
outlet nozzle	20½ ins.

Feed and Filter Tanks.—There is a feed and filter tank of 5,000 gallons capacity in each engine room. The forward end of each tank is arranged as a filter chamber, loufa being the filtering material used. The tanks are covered with hair felt and lagged with galvanized iron.

Feed Pumps.—There are four main and four auxiliary feed pumps, of the Davidson vertical, double-acting plunger type, all of the same size, 14 inches by 10 inches by 15 inches. The main feed pumps are located in the engine rooms, and draw from the main feed tanks, and deliver into the main feed pipes, either through the feed water heaters, or by by-passing. One auxiliary feed pump is located in each fire room, and arranged to draw from the feed tanks in the engine rooms, from the auxiliary drain, from the sea, from the fire room bilge of its own compartment, and from the bottom blow pipes of all boilers in its own compartment. Each delivers into a fore-and-aft feed main leading to all boilers on its own side of the ship, into the fire main, and overboard through a sea valve in its own compartment.

Feed Water Heaters.—There is one feed water heater in each engine room, located on the discharge side of the main feed pumps, well up under the protective deck. The feed water passes through the tubes, and the (heating agent) exhaust steam from the auxiliary exhaust line passes around the tubes

and drains to the main and auxiliary condensers and feed tanks.

Diameter of copper shell (inside) ..... 35 inches.
Thickness ..... 5/16 inch.
Tubes, number, one heater 976
diameter, outside ..... ⅝ inch.
thickness ..... No. 14 B. W. G.
length between tube sheets ..... 6 ft. 0 ins.
Total heating surface (958 sq. ft. each) ..... 1,916 sq. ft.

Auxiliary Condensers.—There is an auxiliary condenser, with combined horizontal air and circulating pump, in each engine room. Each condenser has a cooling surface of 620 square feet. The air and circulating pump has dimensions of 7 inches by 8 inches by 12 inches by 7 inches. There is one auxiliary condenser in lower dynamo room, with a cooling surface of 1,214 square feet. The dimensions of air and circulating pump are 10 inches by 12 inches by 16 inches by 12 inches.

Forced Draft.—The closed fire-room system of forced draft is used. The blowers, eight in number, are of the Sturtevant type, and are located on the protective deck under the breeches portion of the smoke pipes, two for each fire room. The fans are 69 inches in diameter; width of rim at periphery 25 inches. The fans are driven by double upright inclosed engines; cylinders 7 inches diameter by 5-inch stroke.

Hot Well Pumps.—There is one Davidson vertical, single-cylinder hot-well pump, 12 inches by 14 inches by 12 inches, in each engine room. These pumps draw from the main feed tanks, main air pump suction pipes, reserve feed tanks, and from the ship's side above the water line for taking in fresh water, and discharge into the main feed tanks and reserve feed tanks.

Fire and Bilge Pumps.—There is one Davidson fire and bilge pump, of the same size and type as the hot-well pumps, in each engine room. These pumps draw from the sea, the auxiliary drain, the drainage manifolds, the engine-room bilge and crank pits. Discharges overboard and to fire main.

Ash Hoists.—A Williamson ash hoisting engine is located in each fire room hatch inclosure at the main deck level, and operated by means of hand wheels and geared shafting from the hoisting station. From the hoisting stations, the ash buckets are carried by trolley tracks to the ash chutes at the ship's side.

Distilling Apparatus.—The distilling plant consists of four evaporators and six distillers, with their accessories. The evaporators are of the navy type and were designed to have a combined capacity of 21,000 gallons of water per 24 hours. The distillers are vertical, with straight tubes, designed to distil 20,000 gallons of potable water in 24 hours. The test of the plant showed a capacity considerably in excess of the design.

Refrigerating Plant.—One Allen horizontal, dense air ice machine, capable of producing the cooling effect of two tons of ice in 24 hours, supplies cold air to the cold storage rooms, ice-making tank, and scuttle butt.

Engineers' Workshop.—A well arranged workshop is located on the port side of the berth deck abreast of the engine hatch inclosure. A 10-horsepower electric motor drives the following tools:

One 30-inch back-geared, screw-cutting lathe; one 14-inch back-geared screw-cutting lathe, one 16 by 24-inch column shaper, one back-geared drilling machine, one 16-inch sensitive drill, one No. 1 universal milling machine, and one emery grinder.

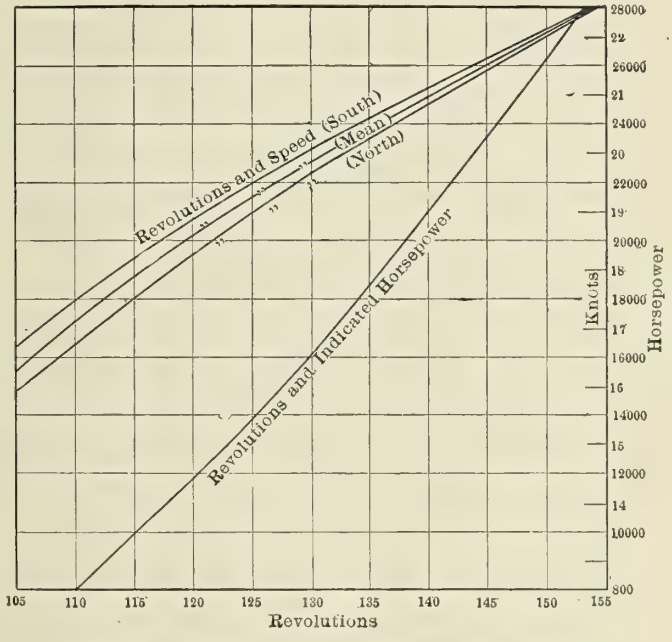
SCREW PROPELLERS.

The propellers have each three blades, adjustable pitch, and are made of manganese bronze. The blades are bolted to the hubs by rolled manganese bronze tap bolts, and secured by lock plates. The blades, hubs and caps are finished smooth and burnished.

Diameter of propeller, feet 18
Diameter of hub, feet and inches 4-7½
Length of hub, inches 45
Pitch of starboard propeller, feet and inches 19-5
Pitch of port propeller, feet and inches 19-4.22
Pitch ratio, mean 1.077
Helicoidal area, each, square feet 91.5
Disk area, each, square feet 231.9
Projected area, each, square feet 76.74
ratio to disk area 0.331

DATA FOR FOUR HOURS' TRIAL.

	Starb.	Port.
Steam pressure at boilers (gauge)	266	
H. P. steam chest (gauge)	235.3	238.2
first receiver (absolute)	103.6	108.8
F. L. P. receiver (absolute)	44.1	43.
A. L. P. receiver (absolute)	44.1	43.
Vacuum in condensers, inches of mercury	26.8	26.7
Mean effective pressures, main engines:		
high-pressure cylinder	111.6	112.3
intermediate-pressure cylinder	40.	43.2
forward low-pressure cylinder	21.8	23.6
after low-pressure cylinder	22.45	22.3



CURVES REPRESENTING RESULTS OF STANDARDIZATION RUNS.

Mean pressure, in pounds per square inch on low-pressure piston, equivalent to aggregate M. E. P. on all pistons	51.87	54.
R. P. M. of main engines (mean)	151.36	150.2
average for both	150.78	
circulating pumps	185.7	188.2
blower engines (8) average	348	
Double strokes of main air pumps	20.5	24.
main feed pumps	28.1	30.8
auxiliary condenser pumps	0.	29.5
sanitary pump	16.9	
fire and bilge pumps	33.3	33.4
Air pressure, in inches of water, average	1.63	
Speed of ship, in knots	22.13	
Slip of propellers, in percent of their own speed, based on mean pitch	22.84	23.67
Indicated horsepower, main engines:		
H. P. cylinder	3,810	3,805.9
I. P. cylinder	3,791	4,061.9
F. L. P. cylinder	2,785	2,992.3

A. L. P. cylinder	2,868		2,833.7
Total	13,254		13,693.8
Total, both main engines		26,947.8	
Indicated horsepower, auxiliaries:			
Main air pumps	10.7		12.4
Main circulating pump engines	73.2		76.
Main feed pumps (2)	67.2		77.
Auxiliary condenser pump	0.		3.2
Sanitary pump		1.5	
Fire and bilge pump	3.8		3.9
Blower engines (8)		122.4	
Dynamo engines		85.4	
Total all auxiliaries		536.7	
Total, all machinery in operation		27,484.5	
I. H. P. (total) per sq. ft. grate surface.		19.8	
" " " heating surface		0.429	
Coal, kind and quality:	Pocahontas, hand picked, excellent		
pounds per hour		44,992	
pounds per sq. foot of G. S. per hour.		32.4	
pounds per sq. foot of H. S. per hour		0.703	
pounds per I. H. P. for all machinery in operation		1.64	
pounds per I. H. P. for main engines, air circulating and feed pumps		1.65	
Cooling surface, square feet per I. H. P.		0.97	
Heating surface, square feet per I. H. P.		2.32	
Temperature, atmosphere, deg. F., average.		53.8	
engine room, upper platform, average.		80.1	
working platform, average		72.2	
fire rooms, above gratings, average		88.	
working level, average		98.	
injection water, average		47.9	
overboard delivery, average		100.6	
hotwell, average		67.7	
main feed, average		130.3	
smoke pipes, base, average		685.	

BUILDERS' TRIAL.

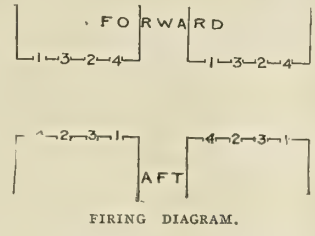
The *St. Louis* left the contractors' yard at 8 a.m. April 4th, and came to anchor outside of the Delaware breakwater at 5 p.m. On the 5th, after adjusting compasses, the ship was headed straight out to sea, making progressive increases of speed for periods of about twenty minutes each, until the maximum was reached and maintained for twenty-five minutes. Forced draft was not used until the last half hour of the run, revolutions up to 120 per minute being easily maintained under natural draft. The machinery, both main and auxiliary, worked very satisfactorily. This trial was made to break in the crew and limber up the machinery.

OFFICIAL TRIALS.

The *St. Louis* left Philadelphia the morning of May 8th for Boston. On the 9th, from 9 to 10.30 a.m., while steaming up the coast, the engines were run at full speed, all machinery running smoothly without heating. Anchored inside of Boston light ship at 9.45 p.m. Went into dry dock, Boston Navy Yard, at noon, May 10th. Left the dry dock at 1 p.m. on the 12th, and proceeded up the coast, coming to anchor at Rockland, Maine, at 8 a.m. the 13th. Before coming to anchor three runs were made over the measured course, to identify the range marks. May 16th the standardization trials were run. Fourteen single runs were made over the course, beginning at 6-52-10.1 and finishing at 9-54-52.5 a.m. The first five runs were made at full speed, the remaining nine at slower speeds, as shown by the table. A mean speed for the first five high-speed runs was 22.123 knots, and was obtained as follows: The five runs were divided into two groups, namely, runs 1, 2, 3 and runs 3, 4, 5. The sum of No. 1 run plus twice No. 2 run plus No. 3 run was divided by four to get the mean of the first group. A mean of the second group was found in the same manner. The means of these two groups were then added and divided by two to get the mean of the five runs, which was used as the high point of the speed curve. The speed curve showed that the *St. Louis* would have to make 149.6 revolutions per minute to make the contract speed of 22 knots. After the standardization runs the ship returned to Rockland and anchored inside the breakwater.

The four-hours' endurance trial was begun at 9.21 a.m. and finished at 1.21 p.m. the 17th. The average speed for the four hours was 22.13 knots, with an average of 150.78 revolutions per minute. The weather conditions were excellent during the trial. The main engines ran smoothly and without the use of water on any of the bearings or working parts. All auxiliaries worked well and at a very moderate speed.

The firing of the furnaces was controlled by electric bells rung by a man with a watch, stationed in No. 4 fireroom. The furnace doors were numbered as per sketch.



FIRING DIAGRAM.

The signal to work the fires was given at intervals of one and a half minutes, the cycle of operation being as follows:

1 bell, rake No. 1, fire No. 3;
2 bells, rake No. 2, fire No. 4;
3 bells, rake No. 3, fire No. 1;
4 bells, rake No. 4, fire No. 2.

There being four furnaces to a boiler, each furnace was fired every six minutes. By this arrangement a very uniform steam pressure was maintained. The fires were kept bright and even, and there was at all times an abundance of steam. The safety valves lifted repeatedly during the trial. The boilers were tight, and showed no signs of the severe demands of the full speed test, notwithstanding that the power developed was far in excess of that designed.

The amount of lubricating oil used during the 12 days' absence of the ship from Philadelphia, including the trials, was 1,982 gallons—less than 40 barrels. Loss of fresh water during the four hours' trial was 17.22 tons. No live steam was used in the receivers during the trial. The steam was cut-off in high-pressure cylinders at 85 percent of the stroke. There were 170 men in the engineering department, including 94 firemen and coal passers.

Value of Naval Architects. There is a general tendency to reduce shipbuilding more and more to a fine art; to appreciate more and more the value of technical training given naval architects, and of a through knowledge of the trade of the world. The movement in favor of a chair of naval architecture at Liverpool and another at Newcastle is gaining ground. Even with these and the one at Glasgow, Great Britain will be far behind Germany and the United States in facilities for technical training. The countries named were the first to realize the value of technical education, and they produced early a large number of students capable of becoming leaders in their different walks of life. In its lack of scientific training Great Britain lost ground in shipbuilding for nearly a century prior to 1860, and to maintain the supremacy of the sea she must see that a race of naval architects is trained to take over the profession as the present generation retires from the field we are occupying so creditably.—*Glasgow Herald.*

COLD STORAGE ON BOARD SHIP.

PART II.

BY SYDNEY F. WALKER, M. I. E. E.

METHODS OF COOLING THE COLD CHAMBERS.

We will now examine the method by which the cold is conveyed to the chambers. Having made a box, so to speak, into which heat is to a certain extent prevented from entering, how is the low temperature to be produced in the box, and how is the heat that does pass through the walls of the box to be carried away? For shipboard work the following methods are permissible: the use of brine, the direct use of carbonic acid where it is the refrigerating agent, and the use of cooled air. With brine and with carbonic acid directly employed, pipes are laid in the chamber to be cooled, usually in the form of a grid, sometimes on the side, sometimes overhead, sometimes, as mentioned above, a grid of pipes separates two bays, and sometimes the pipes are formed into a wall. The length and size of the pipes are calculated from the quantity of produce that is to be stored, and the leakage into the chamber that may be expected. With brine cooling, brine is kept in circulation in the pipes. The brine may consist of salt water—not sea water, but water in which common salt has been dissolved—but it more often consists of a solution of chloride of calcium.

It was mentioned above that dissolving a substance in water lowers the freezing point of the solution, and that is the reason why brine is used. One percent of common salt in water reduces

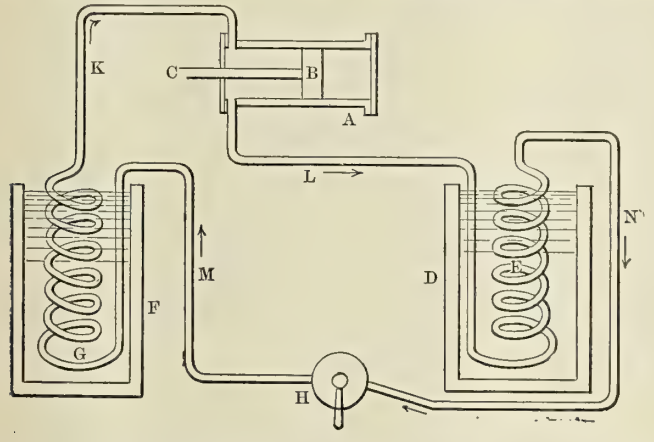


DIAGRAM SHOWING CIRCUIT OF REFRIGERANT.

A.—Compressor. *B. C.*—Piston and Rod. *D. E.*—Condenser and Coils. *F. G.*—Evaporator and Coils. *H.*—Expansion Valve. *K. L. M. N.*—Delivery Pipes.

the freezing point to 30.5 degrees F., 3 percent brings it to 27.8 degrees, 5 percent to 25.2 degrees, and so on. One percent of chloride of calcium lowers the freezing point to 31 degrees F., 5 percent to 27.5 degrees, 10 percent to 22 degrees, 15 percent to 15 degrees, 20 percent to 5 degrees, and 25 percent to —8 degrees. Common salt is not used now, except in special cases, for reasons that need not be mentioned to marine engineers. A 20-percent solution of calcium chloride is usually employed, or, if especially low temperatures are required, a 25-percent solution.

The use of a liquid that freezes at temperatures below that at which the produce is to be held is necessary. The brine itself is cooled by one of the processes that will be described, and it is caused to circulate continually from the tank in which it is cooled, through the pipes connecting it with (and forming) the grid in the cold chamber, and back to the tank again. In passing through the grid in the cold chamber it absorbs heat from the air in the chamber, which in its turn takes heat from the produce, and so on. Heat flows from bodies at higher temperatures to those at lower temperatures, and as the entering brine is at a lower temperature than the air in the room it is to cool, heat flows to it. The brine in the return pipe is, therefore, at a higher temperature than that in the supply pipe, and as the brine which passes through it, back to the evaporating tank where it is cooled, is at a higher temperature than its surroundings in the evaporating tank, heat again flows from it to the refrigerating agent. As explained in connection with the apparatus for "chilled" beef, the attendant knows by the difference between the temperature of the flow and that of the return brine pipes of each particular section of the chamber what work in the matter of cooling is going on, and this applies also to each chamber. It is not a difficult calculation to determine the quantity of brine that must pass through a particular cold chamber in a certain time, to keep the chamber at the required temperature or to reduce the produce to its keeping temperature—having given the number of heat units to be carried away in the same time, ascertained in the manner explained above.

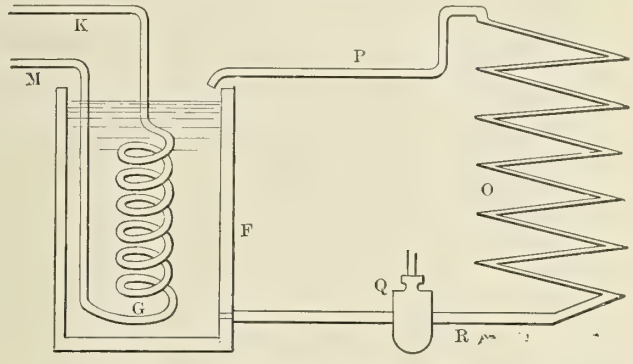


DIAGRAM SHOWING BRINE CIRCUIT.

F. G.—Evaporator and Coils. *K.*—Refrigerant Outlet. *M.*—Refrigerant Inlet. *O.*—Brine Grid in Cold Chamber. *P.*—Brine Discharge Pipe. *Q.*—Brine Pump. *R.*—Brine Pipe Leading to Grid

A 20-percent solution of calcium chloride has a specific gravity of 1.18, so that a gallon (Imperial) of the solution weighs 11.8 pounds. The specific heat of the solution is 0.834, therefore each gallon that passes through the pipes carries off 9.84 heat units for each degree F. that its temperature is raised. Brine is usually worked with an increase of temperature of from 6 to 8 degrees

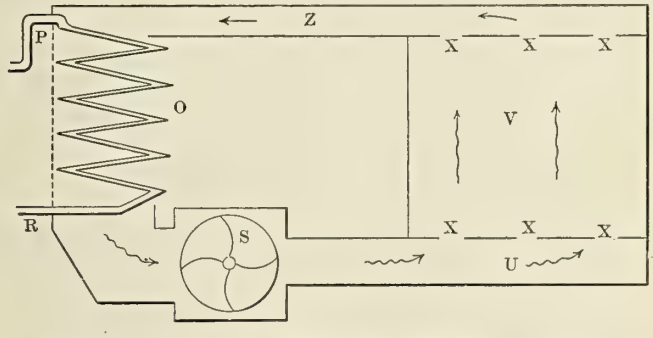


DIAGRAM SHOWING AIR CIRCUIT.

O.—Brine Grid in Cold Chamber. *P.*—Pipe from Evaporator Tank. *R.*—Pipe to Expansion Tank. *S.*—Fan. *U.*—Cold Air Duct. *V.*—Chamber to be Cooled. *X.X.*—Air Ports. *Z.*—Exhaust Air Duct.

F. between the entrance and outgoing ends of the grids, hence if we take an average rise of 4 degrees, since the temperature of the brine will be continually rising as it passes through the pipes, each gallon will carry off 39.36 heat units. The pipe used for brine cooling ranges from 1-inch bore to 2 inches. The external diameter of a 1-inch pipe is 1.3 inches, while that of a 2-inch pipe is 2.4 inches (about). The mean surface of pipe exposed to the heat will be, in the case of the 1-inch, 43.3 square inches per running foot of pipe, and that of the 2-inch pipe 83 square inches per running foot.

If we take Peclet again as a guide, we can calculate approximately the number of heat units that will pass through from the air into the brine in any given time. He gives 230 as the number of heat units per square foot of surface that will pass through

one inch thickness of iron, in one hour, with a difference of temperature of one degree F. The thickness of 1-inch bore iron pipe is approximately 1/8 inch, and of 2-inch pipe 1/7 inch, hence the rate of passage of heat through the walls of the pipe should be respectively 1,840 and 1,610 units per hour per square foot for every degree of rise in temperature of the brine, or again 928 units per running foot with 2-inch pipe, and 550 with 1-inch pipe. In practice the grid is made longer than would be apparently necessary, and more surface is exposed to the action of the heat, in order that the brine may flow at a lower velocity, and also because the results obtained in service do not usually come up to laboratory tests.

There is an important point in connection with this. Power, it will have been observed, is required for abstracting the heat and carrying it away. Where brine cooling is employed, power is required to keep the brine in circulation, and this power is in direct proportion to the extent of the wetted surface of the pipe, and to the square of the velocity at which the brine is flowing. Hence it will be seen that it would not be difficult to add appreciably to the power required by the plant as a whole by giving the brine a high velocity. Practice as usual has solved the question for itself, by the usual methods, and the following figures may be taken as the latest: A cubical space such as that taken, 12 feet on the side, if well insulated, requires, to be held at 32 degrees F., the temperature for "chilled" beef and some other substances, a length of about 432 feet of 1-inch pipe, and about half that length of 2-inch pipe, with roughly proportionate lengths of intermediate sizes. Small rooms require more pipe in proportion than large rooms. Thus with rooms under 1,000 cubic feet capacity 400 feet of 1-inch pipe and half that length of 2-inch pipe is given; while for cold chambers of over 10,000 cubic feet capacity 200 feet of 1-inch pipe and half that length of 2-inch is given, in each case per 1,000 cubic feet.

For lower temperatures, again, longer lengths of pipe are required, and approximately in the following proportions: for a temperature of 10 degrees F., double the lengths of pipe are required that are given for 32 degrees F., and for zero F. temperature about three times that given for 10 degrees. The velocity of the brine is usually kept at or below 3 feet per second. A high velocity has another serious drawback, unless large pipes are employed—all fluids flowing through pipes create friction, which generates heat, and consequently by raising the temperature of the brine lowers its ability to carry off heat from the room it is to cool. Brine coils are made in various lengths, according to the work they are to perform and the sizes of the pipes, from 100 feet with small pipes, for low temperatures, up to 1,000 feet with 2-inch pipes, and higher temperatures.

DIRECT EXPANSION.

By direct expansion is meant the direct action of the refrigerating agent, usually carbonic acid gas, on board ship, except where compressed air is employed in the chamber to be cooled. As will be explained, the refrigerant is caused to assume alternately the liquid and the gaseous state. A compressor and other apparatus are employed to reduce it to the liquid state, in which condition it is conveyed to the expansion coils, consisting of pipes very similar to those that have been described for the brine. The anhydrous liquid, on passing into the expansion coils, being suddenly released from the pressure under which it is held, is reformed into gas; but as a liquid can become a gas only by the addition of the latent heat of the gas, it abstracts this heat from surrounding objects, such as the brine with which the expansion coils are in contact, in the brine tank, or from the air of the chamber in which the coils are placed, where direct expansion is employed. The action, so far as the cooling of the chamber and the produce is concerned, is exactly the same as with brine cooling.

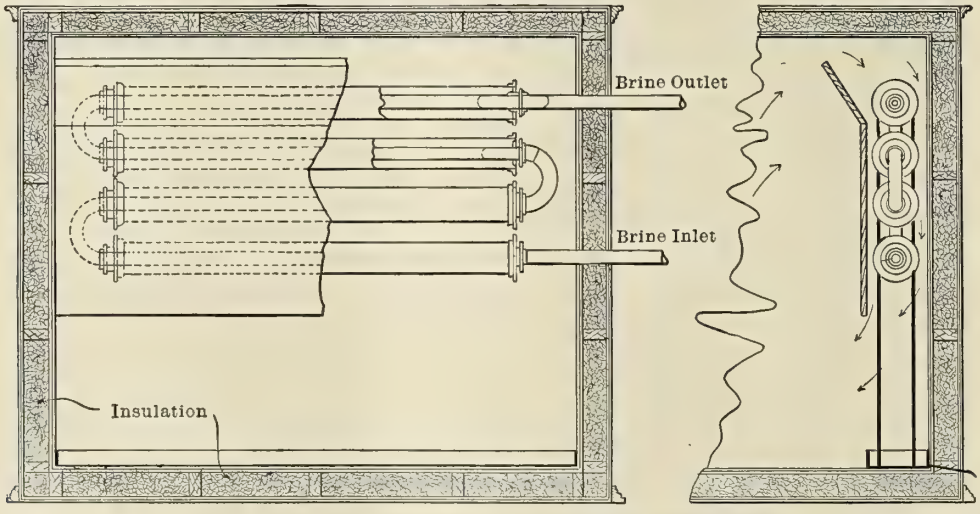
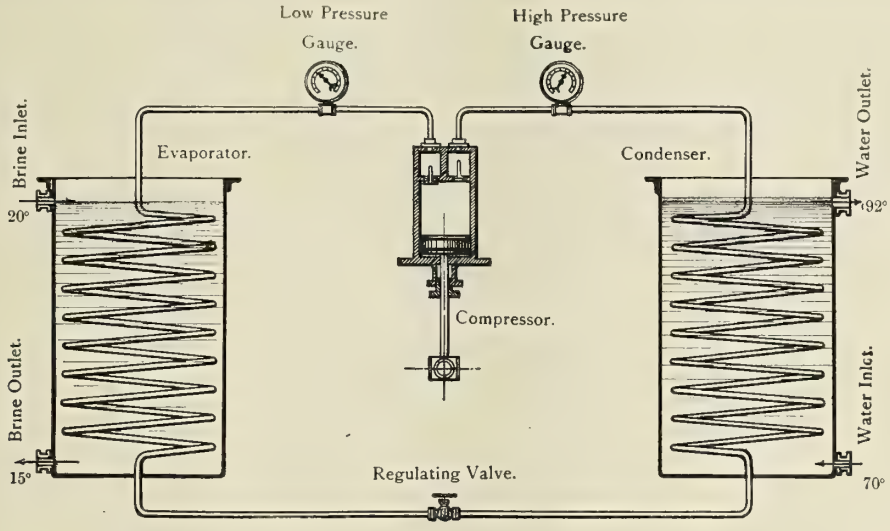


DIAGRAM SHOWING WEST ACCUMULATIVE SYSTEM OF COLD STORAGE.

There is a difference of temperature between the pipe containing the refrigerant and the air surrounding the pipe, because the refrigerant has been lowered in temperature, immediately on its entrance into the expansion coils, by the evaporation of a small portion of itself. Heat passes from the air of the chamber to the surface of the pipe, and thence through the pipe to the refrigerant, this heat enabling more of the liquid to evaporate, abstracting more of the heat from the air, and so on. Heat passes from the produce to the air surrounding it, so long as any difference of temperature exists between them, and hence the produce and the air of the chamber are kept at the temperature required, by the aid of the direct evaporation of the refrigerant, just as by the circulation of the brine. The refrigerant is maintained in continual circulation, just as the brine is; for the compressor, which performs also the duty of a pump, causes it to be continually passing from the condenser to the evaporator coils, thence to the compressor, and to the condenser again, as will be described.

The passage of the refrigerant into the evaporator coils is controlled by an expansion valve, which is practically a stop valve of particular construction. By its aid more or less of the liquid refrigerant is allowed to pass into the expansion coils. The length of the latter can be found by calculation and has also been determined by practice, though the calculation is somewhat different from that for the length of brine coils. Each pound of each kind of refrigerant absorbs a certain number of heat units, in passing from the liquid to the gaseous condition, the number of units absorbed varying with the temperature and the pressure.

Carbonic acid absorbs about 110 heat units per pound at the usual evaporator pressure, in temperate climates, while at higher pressures a smaller quantity is absorbed, 86 units at 650 pounds pressure, and 66 units at 800 pounds pressure. The temperatures corresponding to these pressures are 32, 50 and 68 degrees F. At lower temperatures the pressures are lower, 380 pounds at 14 degrees F., and 288 pounds at —4 degrees F.



KROESCHELL CYCLE OF OPERATION, SIMILAR TO HALL AND LINDE CYCLES.

At 32 degrees F., and the pressure given above, one pound of carbonic acid measures 0.167 cubic feet, or a cubic foot weighs approximately 6 pounds. It will be understood that *volumes* of gaseous substances that are pumped to and fro have to be dealt with, rather than *weights*. One cubic foot of carbonic acid will, therefore, absorb about 660 heat units in passing from the liquid to the gaseous condition at 32 degrees F. The gaseous carbonic acid formed from the liquid also carries off a certain quantity of heat, just as the brine does, but it is bad engineering to allow much of this to be done. The specific heat of carbonic acid gas is 0.2167, so that while one cubic foot of the liquid, in expanding to a gas, abstracts 660 heat units, the same quantity of the gas, in passing through the remaining pipes of the expansion coils, will absorb only 1.3 units, for every degree of difference in temperature between it and the atmosphere of the room.

With direct expansion the lengths of the pipes will be much less than with brine. Ammonia and sulphurous acid are employed as refrigerants, but there is the great objection to direct expansion with ammonia, that the escape of a small quantity of the gas, in the cold chamber, may seriously affect the produce. Sulphurous acid does not labor under that objection, for the substance itself is used as a disinfectant, but it has not so far been much employed on board ship. The calculation for the quantity of the other refrigerants, and the size and length of the pipes, is practically the same, using different constants, as with carbonic acid. Ammonia absorbs 555.5 units per pound at 0 degrees F., while sulphurous acid absorbs 171.2 per pound. It will be understood that the gas which is formed is pumped through the grid of pipes, and thence to the compressor, to be reconverted into liquid, so that the friction of the gas in the pipes has to be taken into account, in the same way as the friction of the brine, and it follows the same laws, depending upon the surface of the pipe rubbed over by the gas, and upon the velocity at which the gas travels. A low velocity is of some value here.

(TO BE CONTINUED)

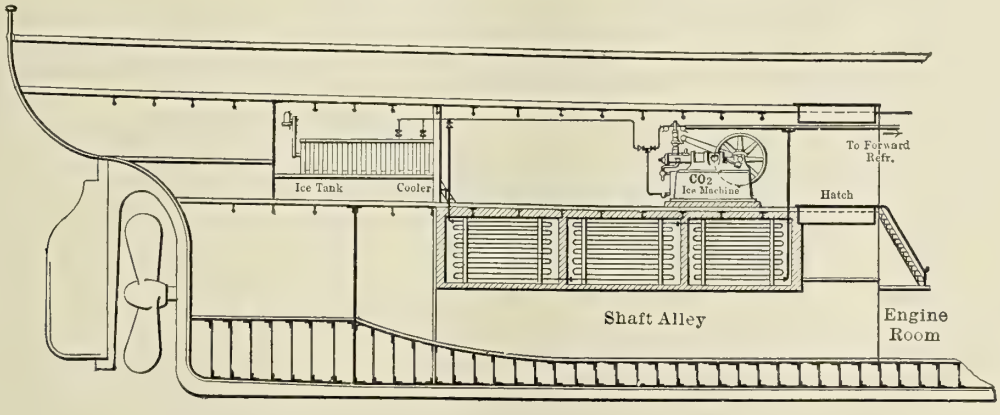


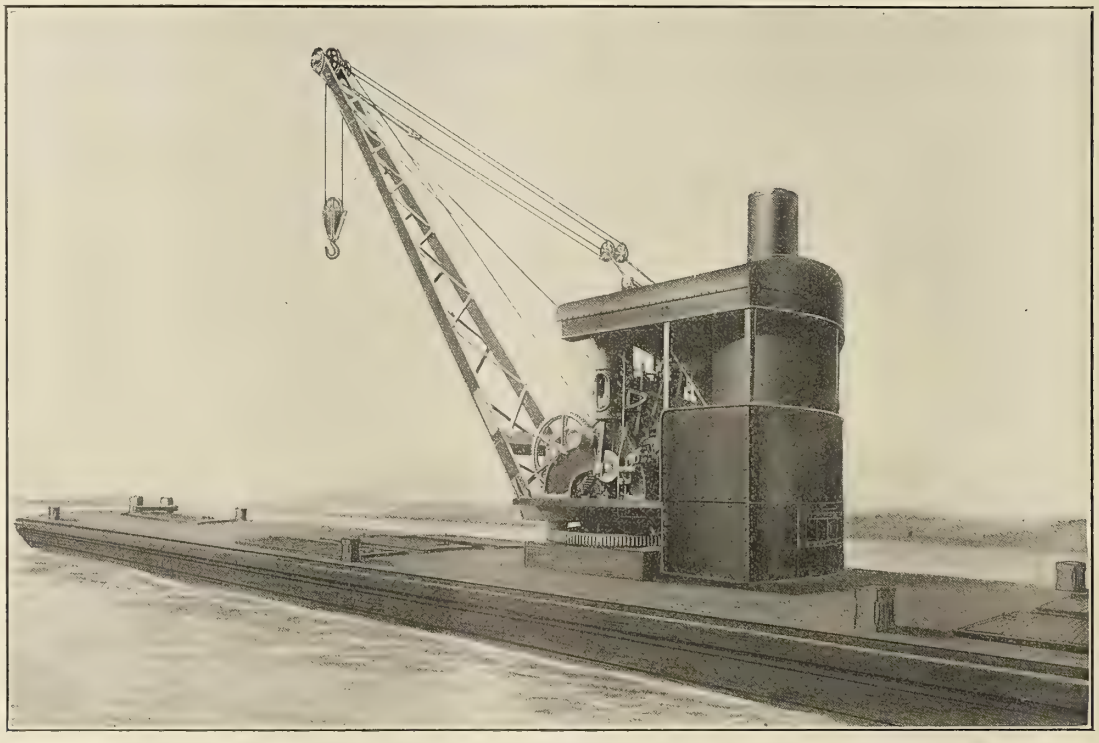
DIAGRAM OF KROESCHELL MARINE PLANT ON MORGAN LINE STEAMSHIP LOUISIANA.

Common Sense Versus Brute Force.

Several years ago I was a passenger on a single screw transatlantic liner operating under one of the foreign flags, and an accident occurred in the engine room which necessitated bringing the vessel to a stop and replacing one of the crank pins. None of the ordinary devices used was successful in even starting the pin from its position, and heroic measures were adopted by bringing down from the deck a heavy carronade, which had been kept there for saluting purposes. This was swung by tackle in such a manner that it could deliver powerful blows against the

end of the crank pin. The successive concussions jarred the entire vessel, but did not produce the desired result.

At this juncture an American gentlemen, of engineering training, offered his services to the captain, stating that he would agree to remove the pin without injury to the machinery or ship, if given a free hand and absolute command in the engine room for a couple of hours. His advances were repulsed until finally, nothing having been accomplished by the engine room staff, they were accepted in desperation.

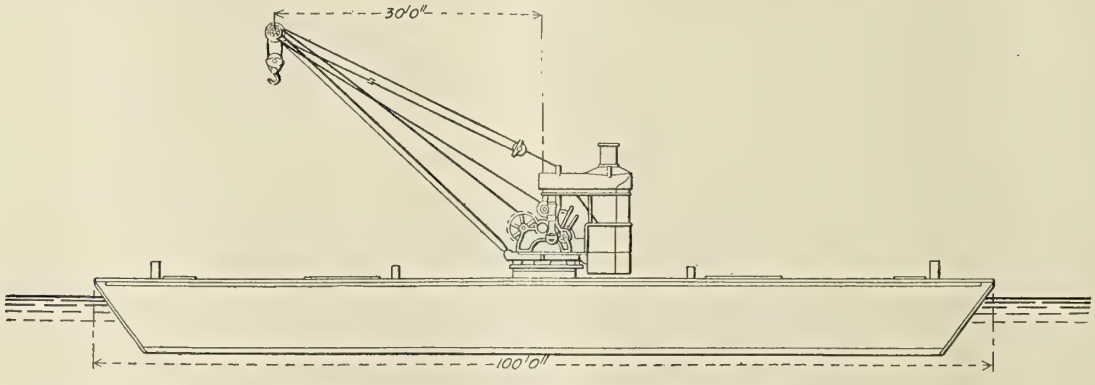


GENERAL VIEW OF DERRICK CRANE MOUNTED ON SCOW.

His method was very simple, consisting merely in building a large fire under and around the crank pin, the exposed parts of the vessel having been previously protected by iron plates. By the time the crank pin had begun to glow with a red heat the expansion had become sufficient to enable the pin to be driven out by a single tap from the carronade. G. M. P.

feet, at which radius the maximum height of lift from the bottom of the hook is 21 feet. The maximum load of 10 tons can be raised at a speed of 50 feet per minute, while a light load can be operated at 125 feet per minute. Complete rotation of the crane with full load can be made in twenty seconds, while without load an entire circumference can be traveled in ten seconds.

It should, of course, be noted that the lifting capacity of the crane at different radii directly abeam is somewhat dependent upon the stability of the scow. In order to increase the stability, and in view of the fact that the scow is narrow, the boiler is swung considerably to the rear of the pivoting point, and a counterweight is placed beneath it to partially balance the weight of the load being lifted. Operation is entirely by means of steam, with the usual drums for wire ropes, the steam being furnished



SIDE ELEVATION OF FLOATING SCOW DERRICK CRANE.

Floating Scow Derrick Crane.

Our illustrations show a new floating crane built by The Wellman-Seaver-Morgan Company, Cleveland, Ohio, for Japan. The crane is very similar to the regular locomotive crane equipment of this company, and is mounted upon the center of a scow having a length over all of 100 feet and a width of 20 feet. The boom has a length of 36 feet, and a radius of action of 30 by a vertical tubular boiler and operating a vertical double-cylinder high-pressure engine fitted with a reversing gear. Two drums are used, one for adjusting the radius of action, and the other for the operation of hoisting and lowering the loads. In addition to this, there is the necessary mechanism for rotation about its axis. The operator's platform is in a cab between the boiler and the engine and drums, and in full view of the work

THE NEW STEEL PADDLE WHEEL EXCURSION STEAMER SOUTH SHORE.

The *South Shore*, which has been built of mild steel throughout, has the following dimensions:

Length over all	205 feet 6 inches
Length between perpendiculars	200 feet 0 inches
Breadth over guards	56 feet 0 inches
Breadth molded	32 feet 6 inches
Depth molded	12 feet 0 inches
Extreme depth to top of dome	33 feet 0 inches

The vessel has been constructed with four decks: lower, main, saloon and hurricane, the three last named being carried out to the extreme width of the vessel, affording great deck area for saloon accommodations and promenading.

On the lower deck forward sleeping quarters are arranged for the crew and firemen, also storerooms and steering engine compartment. Aft a spacious officer's dining room has been fitted up, with crew's mess room and kitchen, and at the extreme after end, cabins for officers and stewards. Leading from this deck to the main deck there are three large stairways.

The main deck forward is bulkheaded off to form freight space, with large gangways opening into same. Abaft these and abreast of the boiler casing, wing houses are built, containing men's toilet and lavatory arrangements, on the starboard side, and on the port side crew's wash room, lamp room, storeroom and check room, while amidships a large lunch room has been built, with hinged shutters opening on three sides. In the midship portion of the vessel on this deck a neatly panelled wood casing has been arranged around the engine hatch and the deck itself carried with an easy slope over the paddle shaft, which is a considerable improvement on the older method of forming a step, and thereby causing a dangerous stumbling block in the passage ways. After wing houses adjoining paddle box have been arranged for the first mate and chief engineer.

Outside of the saloon enclosure proper, the after main deck saloon has been arranged in three compartments, all of them well lighted by large sliding windows. Forward, the quarter deck compartment is handsomely fitted up with mahongany dado and panelled sides finished in white and gold with artistic frieze. At each side there are spacious mahogany stairways leading to the saloon deck above. Immediately aft of these spaces the ladies' cabin is located, fitted with olive colored plush sofas and finished in a similar manner to the quarter deck inclosure. At the extreme end of the house, ladies' lavatories, etc., have been arranged. There is ample walking space around this house on the outside, with deck lights arranged underneath the seats for lighting officers' quarters on the lower deck.

The saloon deck extends for about seven-eighths of the entire length of the vessel, and has a panelled deck house for about one-half this length, lighted by large sliding windows, and upholstered, with cane bottomed chairs arranged around the sides in groups, and in the center line. This saloon will provide those passengers with shelter from wind and sun who do not care to avail themselves of the promenade outside. On each side, at the forward end of paddle boxes on this deck, the purser's room and directors' room are located.

The hurricane deck is built on top of the saloon deck house, for one-half its length, and has a large well-lighted dome supplying light and air to the saloon below. Arranged around the after end are slat seats, and at the forward end there is a commodious house fitted up as captain's, pilot's, mate's and quartermaster's cabins, with pilot house at the extreme end of these. Ten life boats are stowed on this deck, with facilities for handling them rapidly in case of emergency.

THE NEW NANTASKET BEACH STEAMER SOUTH SHORE.

The propelling machinery consists of one set of compound diagonal surface condensing engines, supplied with steam by two large boilers, the installation aggregating 1,200 horsepower, which will give the vessel a speed of about 15 miles per hour.

The *South Shore* is lighted throughout by electricity, and in addition a powerful searchlight has been mounted on top of the pilot house, and a number of large deck lights arranged in the open for illuminating the promenades at night.

Altogether the vessel is a notable addition to the already large fleet of the Nantasket Beach Steamboat Company. With her great accommodations, modern methods of construction, and the ample conveniences provided for the comfort of passengers the steamer should prove one of the best and most popular excursion vessels on the Atlantic coast.

Everything that forethought could suggest with a view to insuring the safety of the passengers has been incorporated on this vessel, comprising life boat, life raft and life belt capacity to take the entire complement of 2,300 people. Numerous hydrants, with their attendant hose lengths, have been arranged in easily accessible locations, and, most important of all, there is a more minute sub-division of the steel hull than has been hitherto attempted in this class of vessel, so that, in the event of a collision, the vessel's buoyancy will be interfered with to

a minimum. It is well within the bounds of moderation to assert that this vessel in equipment, design and construction is probably in advance over any vessel at present plying in these waters.

She was built by the Fore River Shipbuilding Company, of Quincy, Mass.

MOTOR BOATS.

PART XIV,

BY DR. WILLIAM F. DURAND.

PROPELLER DESIGN.

The problem of propeller design forms naturally an integral part of the general problem of speed and power; for no matter how accurately the power provided may be suited to the speed desired, the latter will fail of realization unless the boat is provided with a propeller suited to the efficient absorption and transformation of such power into the work of boat propulsion. In fact all formulæ and methods for determining the power suited to a desired speed are based on the assumption of a reasonably efficient propeller, and without such propeller all such formulæ and methods as those discussed in the preceding chapter are meaningless.

The general problem of propulsion is, if possible, more complex than that of ship resistance, and in these pages we shall not undertake any detailed consideration of this problem. It will be sufficient to note that the propulsion of a boat requires the development of a propulsive thrust sufficient to balance and overcome the resistance opposed by the water to the motion of the boat. This propulsive thrust may be viewed in two ways: (1) As the reaction resulting from the sternward acceleration of a column of water which is laid hold of by the propeller in a condition of rest and given a motion sternward or opposite to that in which it is desired to propel the boat. (2) As the resultant of the resistance which the blades of the propeller meet with in passing through the water, such resultant due to the oblique form of the blades having a forward component and constituting the propulsive thrust. The two methods are of course fundamentally the same, and represent different view points for the same phenomenon.

In no case is any complete rational theory of the screw propeller possible in the present state of our knowledge, and for practical purposes, therefore, methods must be devised in which the chief characteristics of the propeller are connected by means of empirical factors or constants with the conditions to be fulfilled.

Including a reasonably adequate analysis, the performance of a propeller may be reduced satisfactorily to its dependence on the following features:

(1) Diameter.
(2) Pitch.
(3) Revolutions.
(4) Slip at which operated.
(5) Blade area.

Of these items, numbers (1) and (2) determine between them the pitch ratio, while (2), (3) and (4) determine the speed.

Before proceeding with the discussion of actual formulæ for screw propeller design, reference must be made to the double aspect in which the term *slip* may present itself for consideration.

If we suppose a propeller of pitch p and revolutions N working in undisturbed water at a speed of advance v feet per minute, then the actual slip is $(p N - v)$ and the slip percent is $(p N - v) \div p N$. This is the so-called true slip, and is reckoned relative to the water close about the propeller and in which it is working. Now, when a boat is propelled through the water, the action of the boat on the water is to produce, as is well known, a following current or wake, most noticeable close about the stern. It is therefore in this wake or current of water which is moving forward relative to the surrounding body of still water that the propeller must work, while it is relative to the surrounding body of still water itself that speed is judged. It thus follows that the speed of the boat and the slip of the propeller are not determined from the same standard, and that the speed of the boat relative to the wake is less than that relative to surrounding still water, while the slip is correspondingly greater. The slip relative to the wake, however, must be the true slip, since it is in the wake water that the propeller is working. The decreased slip relative to the surrounding body of still water calls therefore for separate recognition and is known as the *apparent* slip.

The formula for apparent slip is thus the same as that given above for the true slip, but in this case v must be understood as referring to the speed of the boat through the still water. In any given case the difference between the two values of the actual slip is, of course, the speed of the wake or following current. In percentage of the product $p N$, the difference may vary widely between little or nothing for short, narrow fine lined boats with the torpedo boat or modern stern, to 20 percent or more for large full boats with the older form of stern. Its value is furthermore distinctly less with twin than with single screws.

The performance of a propeller, so far as efficiency is concerned, and as an actual instrument of propulsion, must be judged, of course, relative to the water in which it is working; while so far as speed is concerned, it must be judged relative to the surrounding body of still water. In any method of propeller design providing for a recognition in detail of all the various factors which exercise a controlling influence, this double aspect of the slip must be recognized, with an estimate of the difference between the two values in any given case.

It should be understood at this point that the method of propeller design here proposed is not intended to provide in detail for the recognition of all of the factors and influences above noted, and in particular for a detailed recognition of the influence due to the wake. It is intended rather as a convenient and relatively simple method for the guidance of those who are not experts in this field, but who may wish to derive the dimensions of a propeller with some assurance of a reasonably satisfactory result.

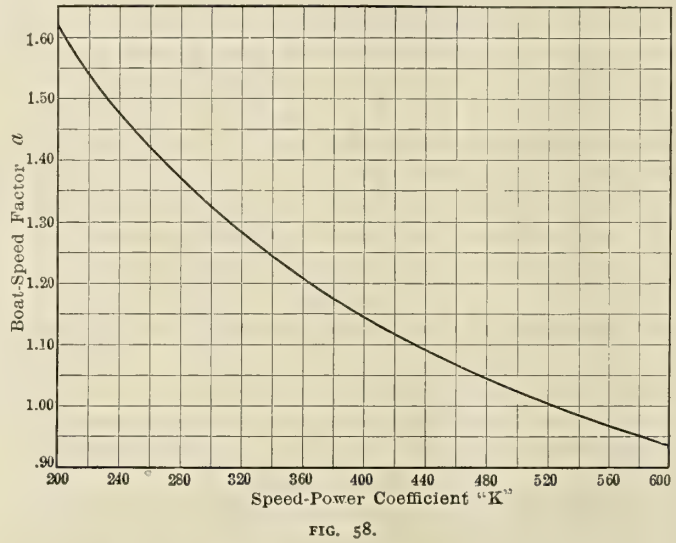


FIG. 58.

Turning now to the development of actual formulæ and methods, we first note that in the formula for power as discussed in the preceding chapter, the relation between power and speed is made to depend on the cube of the latter. It is furthermore a fact that in all formulæ for propeller performance, no matter how disguised, the power absorbed by the propeller is also held to vary with the cube of the speed. It would

therefore seem natural to expect that, by an appropriate combination of these two formulæ, we should be able to eliminate the item of power, and thus relate the dimensions of the propeller directly to those of the boat and to the other general conditions of the problem. Such a direct relation of the propeller to the boat is not unreasonable when we remember that in effect it is the resistance of the propeller which provides the propulsive thrust for overcoming the resistance of the boat. There is thus a balance between the resistance of the boat and the fore and aft component of the resistance experienced by the blades of the propeller, and under such circumstances it seems reasonable to assume that the size of the propeller may be related directly to the size of the boat, the details of the relationship being made to include the speed and such other special items of the case as the data in hand will permit.

A further reason for the convenience of a formula of this character is found in the fact that frequently the size, weight or displacement of the boat is known independently of the power or speed, and it may be desired to determine the size of propeller independent of the special question of power The problem thus becomes one of fitting to a given boat a propeller such that whatever the power, it will be economically absorbed for propulsive purposes, and such speed realized as may properly be expected under the conditions.

We will now proceed with a statement of the formula proposed, and its illustration by numerous examples.

Let W = weight or displacement of boat in pounds, or in case of twin or triple screws, weight divided by 2.83 or 5.2 respectively.
v = speed in miles per hour.
d = diameter of propeller in inches.
p = pitch of propeller in inches.
N = revolutions per minute.
a = boat speed factor, derived from Fig. 58.
b = slip factor, derived from Fig. 59.
c = pitch ratio factor, derived from Fig. 60.
e = area factor, derived from Fig. 61.
s = apparent slip.

Then we have:

$$d = a\ b\ c\ e\ \sqrt[3]{W} \quad \ldots\ldots (1)$$

$$N = \frac{1056\,v}{p\,(1-s)} \quad \ldots\ldots (2)$$

$$s = \frac{pN - 1056v}{pN} \quad \ldots\ldots (3)$$

$$p = \frac{1056\,v}{N\,(1-s)} \quad \ldots\ldots (4)$$

The fundamental equation (1) signifies simply that for single screw boats the diameter of the propeller in inches is equal to the cube root of the displacement or total weight in pounds multiplied by the combination factor $a\ b\ c\ e$, the values for which are to be derived from the special circumstances of the case. For multiple screws the operation is the same except that for W a certain fraction of the total weight is to be taken as noted above. The fundamental equation will thus serve to determine the diameter, and from this the pitch, revolutions and surface area will result directly from the various special assumptions which have been made in connection with the factors b, c, e.

On the other hand, if the revolutions, diameter or pitch is fixed in advance, some one of the factors b, c or e will be left to be determined by the fundamental equation, and the possibility of a satisfactory solution with the assumed values will be indicated by the resulting value of such factor. These various points will be made clear by means of illustrative problems to follow.

We must first, however, discuss briefly the character of the factors a, b, c, e.

The boat-speed factor is intended to take account of the dimensions and form of the boat, especially in relation to the expected speed. In Fig. 58, values of this factor are plotted on an axis of values of the Admiralty displacement or speed-power coefficient K, as used in the formula for powering. The values of a are in fact equal to $\sqrt{524 \div K}$. Reference may therefore be made to the discussion regarding suitable values of K, previously given in connection with the speed-power problem, and the same value of K used in Fig. 58 will then serve to indicate a suitable value of a. For reasons of numerical convenience the standard value of $a = 1$ is taken to correspond to $K = 524$. Remembering then that the usual values of K range from 200

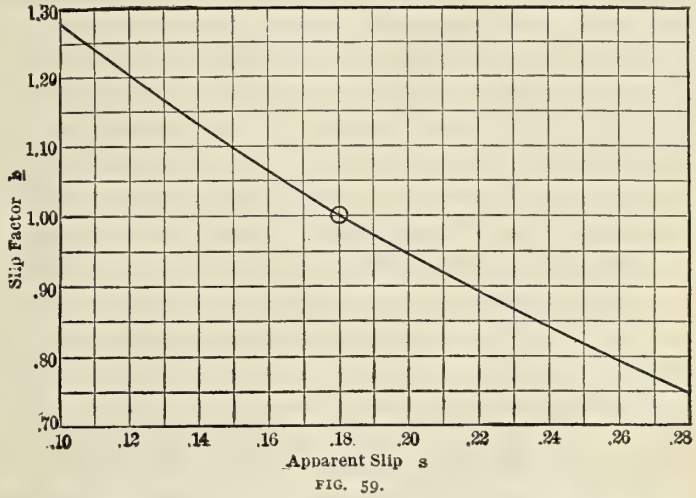


FIG. 59.

or 250 to 500 or 550 it follows from Fig. 58 that the corresponding values of a will range from close about 1 upward to about 1.5.

The slip factor b is intended to provide for the increasing thrust which is obtained with increasing slip, and the consequent permissible reduction in the diameter of the propeller. The slip is one of the conditions which must usually be assumed in the solution of the problem, and the value first assumed must often be modified in order to finally reach an adjustment of the result complying with the main conditions of the problem. It will be noted that the slip used in Fig. 59 is the *apparent* and not the

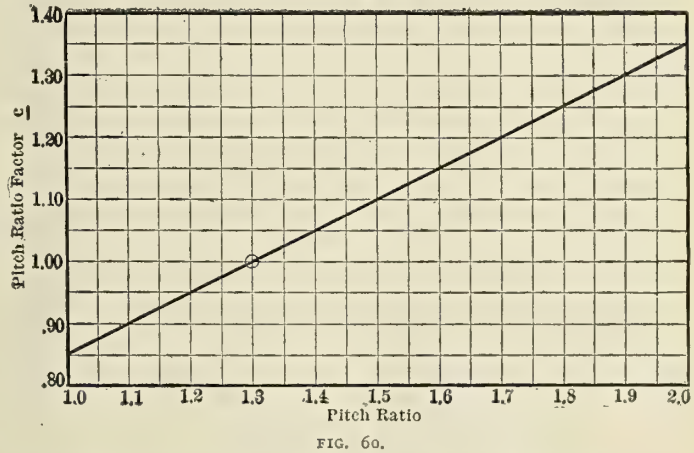


FIG. 60.

true slip. Reference may also be here made to the discussion of the difference between these two terms, which has been presented at an earlier point in connection with the speed-power problem. A strictly rational analysis of propeller action would require an estimate of the wake influence, and thus of the difference between the two values of the slip. For purposes of simplicity, however, we have assumed a standard value of the wake of ten percent of the speed of the ship, and have arranged the values in Fig. 59 on this assumption. For the purposes for which this manual is intended, the error involved in this assumption will usually be unimportant.

The pitch-ratio factor e is intended to take account of the fact that, other things being equal, the higher the pitch ratio the

lower the thrust, and *vice versa;* with corresponding effect on the necessary diameter of the propeller. The selection of a pitch-ratio is often a matter of arbitrary choice, and the value first selected may frequently require re-adjustment, either to bring the revolutions within a suitable limit, or to make possible a satisfactory result on a specified diameter. These points will appear more clearly in connection with the illustrative problems given at a later point.

The surface-area factor e is intended to provide for the slowly increasing thrust with increase of area. The standard form of blade assumed is supposed to be elliptical or oval in contour, and the standard surface area is taken as .40 of the disk area of the propeller. For such area the value of the factor is 1, while for other values of the area ratio the values are as given by the diagram of Fig. 61. Detailed investigations on the influence due to area show that it depends on both pitch ratio and slip, but for simplicity the indications of the diagram are intended to apply more especially to average values of the slip, and to values of the pitch ratio close about 1.3.

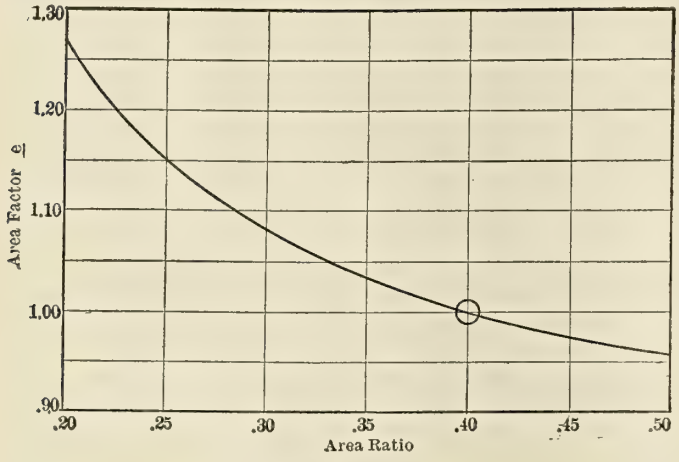


FIG. 61.

With regard to area-ratio, its usual value for propellers of two, three and four blades may be indicated as follows:

Let d = diameter of propeller.

A = total blade area.

Then area-ratio $= A \div \left(\frac{\pi d^2}{4}\right)$

For two blades, area-ratio is usually found between .20 and .25;
For three blades, area-ratio is usually found between .30 and .40;
For four blades, area-ratio is usually found between .35 and .50.

ILLUSTRATIVE PROBLEMS.

We shall here take, in general, the same cases used for illustration in the speed-power problems of the preceding chapter.

(1) Given L = 36 feet,
W = 12,000 pounds,
speed = 9 miles per hour,
One propeller, four blades.
Assume K = 300.
Then a = 1.32.
Take trial slip = .18 and pitch ratio = 1.3,
Then b = 1,
c = 1.
Assume standard area ratio.
Then e = 1.

We then have:

$d = 1.32 \sqrt[3]{12{,}000} = 1.32 \times 22.89 = 30.21$ inches.

$p = 1.3 \times 30.21 = 39.27$ inches.

$$N = \frac{1056 \times 9}{39.27 \times .82} = 295$$

This propeller is readily seen to have an excessively large diameter and pitch, with correspondingly low revolutions. The trial assumptions should therefore be so modified as to reduce the dimensions and increase the revolutions.

To show the influence of a single change, let us take pitch ratio = 1.2. Then c = .95 and we have:

$d = 1.32 \times .95 \times 22.89 = 28.7.$

$p = 1.2 \times 28.7 = 34.44.$

$$N = \frac{1056 \times 9}{34.44 \times .82} = 336$$

Again, let pitch ratio = 1.1. Then c = .90 and we have:

$d = 1.32 \times .9 \times 22.89 = 27.19.$

$p = 1.1 \times 27.19 = 29.91.$

$$N = \frac{1056 \times 9}{29.91 \times .82} = 387$$

Again, with pitch ratio = 1.1, let slip = .20, and we have b = .95, c = .9. This gives:

$d = 1.32 \times .95 \times .9 \times 22.89 = 25.83.$

$p = 1.1 \times 25.83 = 28.41$

$$N = \frac{1056 \times 9}{28.41 \times .80} = 418$$

Any one of these several propellers might be expected to develop the desired speed on approximately the indicated revolutions, and in general to effectively take its part in the attainment of any speed of which the conditions will permit. Still further decrease in dimensions and increase in revolutions can be made if desired. These successive steps are given to show the method of gradually approaching a combination result which shall satisfy the general requirements regarding these various features. In the remaining problems the values will be so chosen as to give immediately a more satisfactory series of values.

(2) Given L = 33 feet.
W = 3600 pounds.
Speed = 15 miles per hour.
One propeller, four blades.
Assume K = 300.
slip = .18.
pitch ratio = 1.4.
Then a = 1.32, b = 1.00, c = 1.05 and take e = 1.00.
Then we have:

$d = 1.32 \times 1.05 \times \sqrt[3]{3600} = 21.25$ inches.

$p = 1.4 \times 21.25 = 29.75$ inches.

$$N = \frac{1{,}056 \times 15}{29.75 \times .82} = 649.$$

$A = .40 \times 353.6 = 141$ square inches.

Such a propeller might then be reasonably expected to develop a speed of 15 miles per hour on about 650 revolutions per minute, or any proportional speed on approximately corresponding revolutions, and in general to efficiently do its part in the attainment of any speed of which the controlling conditions will permit.

(3) Given L = 24 feet.
W = 4800 pounds.
Speed = 7 miles per hour.
One propeller, four blades.
Assume K = 250.
slip = .20.
pitch ratio = 1.0.
We then have:
a = 1.45
b = .95
c = .85
e = 1.00

$\sqrt[3]{4800} = 16.87$

Hence $d = 1.45 \times .95 \times .85 \times 16.87 = 19.75$ or say 20 inches

$p = 1.0 \times 20 = 20$ inches

$$N = \frac{1056 \times 7}{20 \times .80} = 462$$

(4) Same as problem (3), but driven at speed of 8.5 miles, and with value K reduced to 200. Then $a = 1.62$ and with the other assumptions as before we should have:

$d = 1.62 \times .95 \times .85 \times 16.87 = 22.07$ or say 22 inches

$p = 1.0 \times 22 = 22$ inches

$$N = \frac{1056 \times 8.5}{22 \times .80} = 510$$

(5) Given $L = 56$ feet

$W = 12{,}000$ pounds

Speed $= 25$ miles per hour

One propeller, four blades

Take K $= 350$

Suppose N fixed at 1000.

Then we proceed as follows:

Assume slip $= .18$ and pitch ratio $= 1.2$, leaving e to be determined. Then:

$$p = \frac{1056 \times 25}{1000 \times .82} = 32.2 \text{ inches}$$

$d = 32.2 \div 1.2 = 26.83$, or, say, 27 inches.

Then to test the possibility of such a propeller we substitute in formula (1) and find the resulting value of e thus:

$27 = 1.22 \times .95\ e \times \sqrt[3]{12{,}000} = 26.53\ e$

or $e = 27 \div 26.53 = 1.018$

This value of e is only slightly larger than 1.0, and denotes therefore an area ratio slightly larger than .40, or otherwise, with area ratio .40, the indications are that with the same propeller the slip would slightly increase and the revolutions rise slightly above 1000. In either case the propeller should substantially realize the conditions imposed. In case a pitch ratio greater than 1.2, such as 1.3 or 1.5, had been assumed, the resulting value of d would have been too small, and the value of e would have resulted much less than 1.00. Any such value as .8 or .9 for e thus indicates an impossible propeller, or an impossibility of fulfilling the conditions on the diameter indicated. On the other hand, should the value of e result much larger than 1, it shows that the diameter may be reduced, and still provide for the realization of the conditions imposed. A value of e slightly larger than 1.00 denotes, of course, an area ratio less than .40, in accordance with the indications of Fig. 61. In any case, where the resulting value of e does not agree with the indications of Fig. 61, changes must be made in the pitch ratio assumed, and thus by successive trials a final satisfactory combination result may be realized.

(6) We will assume the same data as in (5), but with twin screws. Then we have $12{,}000 \div 2.83 = 4240$, and $\sqrt[3]{4240} = 16.19$. Now assume a pitch ratio of 1.45, and slip $= .18$, as in (5). Then we have:

$a = 1.22$

$b = 1.00$

$c = 1.075$

$d = 32.2 \div 1.45 = 22.2$ inches.

From formula (1):

$22.2 = 1.22 \times 1.075\ e \times 16.19 = 21.23\ e$

or $e = 22.2 \div 21.23 = 1.046$.

This value of e indicates an area ratio of .36 or .37, a value suitable for three blades, which are very commonly used for twin screw propellers.

(7) Given $L = 40$

$W = 5000$

Speed $= 28$ miles

Take $K = 500$

slip $= .18$

pitch ratio $= 1.6$

area ratio $= .40$.

Then we have:

$d = 1.025 \times 1.15 \times 17.1 = 20.15$, or say, 20 inches

$p = 1.6 \times 20 = 32$ inches

$$N = \frac{1056 \times 28}{32 \times .82} = 1127$$

(8) Given $L = 41$

$W = 3300$

Speed $= 26$ miles

Take $K = 500$

slip $= .16$

pitch ratio $= 1.9$

area ratio $= .40$

Then we have:

$d = 1.025 \times 1.06 \times 1.30 \times 14.89 = 21$ inches

$p = 21 \times 1.9 = 39.9$, say, 40 inches

$$N = \frac{1056 \times 26}{40 \times .84} = 817$$

In example (7) the values are so selected as to give a relatively small propeller with high revolutions; while in (8) the values are selected so as to give a larger diameter (though the boat is smaller) and with a marked reduction in revolutions. These two examples illustrate typical cases with extreme speeds, and indicate the wide range of flexibility of which the designer may take advantage in adapting his designs to the various special conditions of the problem.

GAS POWER FOR MARINE WORK.

BY GODFREY M. S. TAIT.

There is one great drawback to the continued use of fair sized gas engines, and that is the cost of the gasoline fuel, and it is with a view to offering a remedy for this drawback that the writer has investigated the gas producer as a fuel generator for this class of work.

It is an accepted fact that producer gas operated gas engines comprise the very cheapest method of power generation, and when in combination with this advantage we find that we can operate a plant of this description, by means of recent improvements, without the use of any fresh water whatever, and that the weight of the fuel (coal) does not exceed that of an amount of gasoline capable of doing the same work, the whole proposition appeals to us strongly.

Builders both here and abroad are now devoting their energies to working out a practical design with this type of power, and to a large extent their efforts have been crowned with success.

One of the problems which presented itself to the European builders when they came to redesign the gas producer for marine work consisted in the fact that a considerable quantity of fresh water had to be carried for use in the "evaporator," from which steam is drawn to be utilized as a means of preventing clinkering, and enriching the gas in the producer. This drawback bade fair to prove a serious one, but has now been overcome in this country by the patenting of a process of producer gas generation in which the use of steam or water vapor has been entirely eliminated, the place of the steam being taken by the exhaust gases from the engine, which are found to have a sufficient cooling effect, chemically, to thoroughly retard clinkering in the producer, while at the same time causing the generation of a gas absolutely free from hydrogen. The use of this process was found in practice not only to accomplish the results above mentioned, but in addition was found to generate gas of such a constant composition that analyses taken at frequent intervals during a 24-hour run, recently made by the writer, showed a variation of less than five percent in heating value.

With a producer operating under these conditions, practically all danger from unreliable service is eliminated, while such occurrences as back-firing, pre-ignitions, etc., are entirely eliminated by the constant quality of the gas.

A marine power plant designed by the writer for installation on a 55-foot pleasure craft embodies in its design the improvements above mentioned.

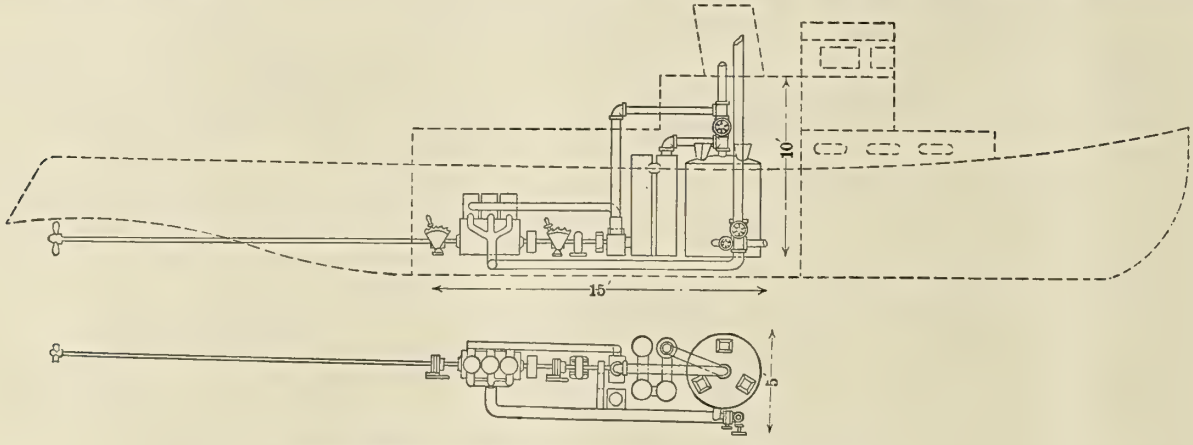
The plant, which is shown in illustration herewith, and which is of 50 horsepower capacity, consists of a producer of special design, having its gas outlet in the center, and connected to four small cooling towers connected up in series, through which a spray of salt water is continually passing. From these cooling

towers the gas passes to a tar separator or fan, which, in addition to throwing off by centrifugal force the tarry particles, also removes the moisture, so that the gas, which is piped direct from the separator to the engine, is sufficiently dried to enable the engine to operate steadily.

The engine shown in connection with this plant is built by the Brownell-Trebert Company, and was selected on account of its valve design, which admits of ready alterations so as to enable the engine to operate under 200 pounds compression, which is required with this type of gas.

deck line; the producer room being provided with hatches which are adapted to raise up when it is necessary to poke the fire or work around the top of the producer. The latter is equipped with a revolving grate of special design, which has a shearing effect upon the clinkers, and by means of which the fuel bed can be steadily lowered as the combustion takes place, the ashes falling into the ash pit, whence they can be removed once in eight or ten hours.

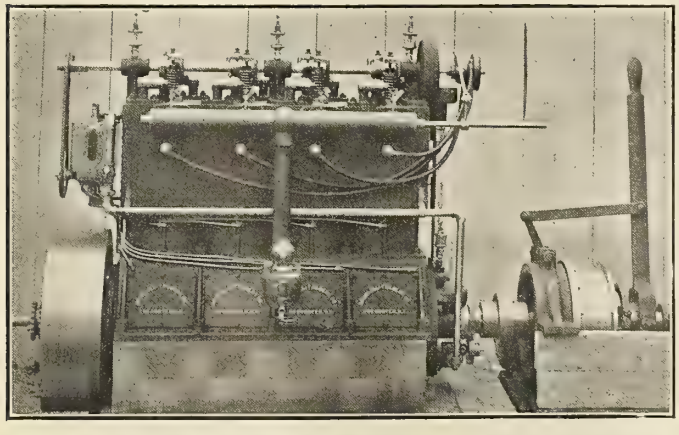
While this producer is designed for operation on anthracite coal, bituminous fuel may also be used when necessary, without



OUTLINE DESIGN OF VESSEL TO BE PROPELLED BY PRODUCER GAS PLANT.

While it is not essential that engines with the valves opening directly into the cylinder head should be used with this system, it is found very much easier to make the equipments on this type of engine, while the efficiency obtained is considerably higher, due to the reduction in thermal losses from jacket water, as with this design practically all the compression space is utilized to exert a direct downward thrust to the piston head.

In this equipment it will be noted that in order that the engine might be enabled to operate in a horizontal position the propeller shaft terminates in a well (as can be seen in the cut illustrating the side elevation of the boat), of such design that when the boat is in motion the water will entirely fill this well and thereby cover the propeller blades. This arrangement was originally designed for boats operating on the Nile, where shallow draft was a necessity, but where screw propellers were preferred to side paddles, and the ingenious arrangement of using a well above the water line, which would be maintained full of water by the action of the propeller when in motion, was found to be eminently satisfactory, besides doing away with the pitch of the propeller shaft.



MOTOR FOR USE WITH PRODUCER GAS OUTFIT.

The producer, as well as the engine, is situated forward of the cabin, and the top of the former comes about flush with the

interfering with the general operation, of the plant, the only change necessary in running being that constant poking is required with this latter type of fuel, due to its caking tendency.

In addition to the equipment mentioned, there is also an auxiliary 3-horsepower gasoline engine used for the purpose of running the air compressor for starting the engine, and also for blowing up the producer after it has been banked for any length of time. The lay shaft from this outfit is so arranged that when the main engine is in operation both the air compressor and blower may be operated direct, allowing the gasoline engine to come to a state of rest.

On the main shaft of the engine are located the tar separator and driving fan, and also the centrifugal pump which supplies water to the scrubber and the cylinder jackets. The engine is supplied with the usual form of reversing gear.

The total weight of this plant, including engine, producer, scrubber, auxiliary engine, etc., will not exceed 5 tons, and the space occupied is such as to leave ample room on the craft for other purposes. This boat is designed to carry one-half ton of coal in addition to what is in the producer, this being sufficient to operate the engine at full speed for ten hours, but should it be desired, additional stowage for coal could easily be arranged.

The labor required for this plant would be the services of one man to run the producer and engine, the same man being enabled to steer the boat most of the time, as the attention required by the producer is of an intermittent character.

A plant similar to the foregoing, but designed for stationary purposes, was recently tested by the writer in a 24-hour run at a slight overload capacity, and was found to consume 1⅛ pounds of coal per brake horsepower per hour, the horsepower being measured by means of a water cooled prony brake. This plant operated without any shut-downs during this entire period, even when the fire was cleaned thoroughly, which occurred once in eight hours, and at no time was there any trouble from back-firing, pre-ignitions, etc.

In designing or purchasing a gas-producer-gas-engine operated craft the following desirable items as regards the power plant should be carefully borne in mind:

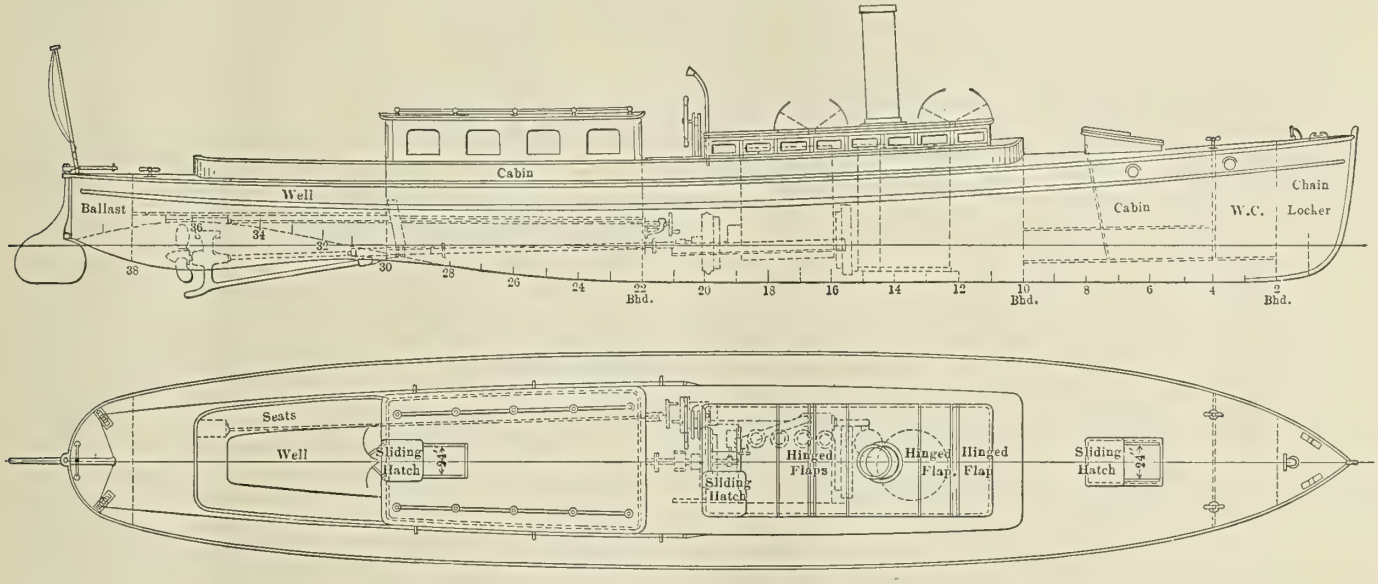
Compactness of design, minimum weight, ease of attendance, capacity to operate at full load for long periods, low first cost,

adaptability to operate on various sizes and grades of fuel, economy of operation, use of little if any fresh water.

If these points are carefully looked after there is now no reason why a gas-producer-gas-engine plant should not fill, with entire satisfaction, all the requirements of power propulsion for small craft at least, and in the course of a few years it is not unreasonable to expect to see some large ships also using this type of equipment.

pelled by self-produced gas. We reproduce drawings illustrating this vessel and her engines and gas plant. The *Dalmuir* is 60 feet in length by 10 feet beam and 2 feet 6 inches deep. The reversing is done by means of a reversing propeller.

The vessel is fitted with the Thornycroft marine gas plant (Capitaine system), which consists of a suction gas producer in which the gas is generated, and an internal combustion engine working on the usual Otto cycle.



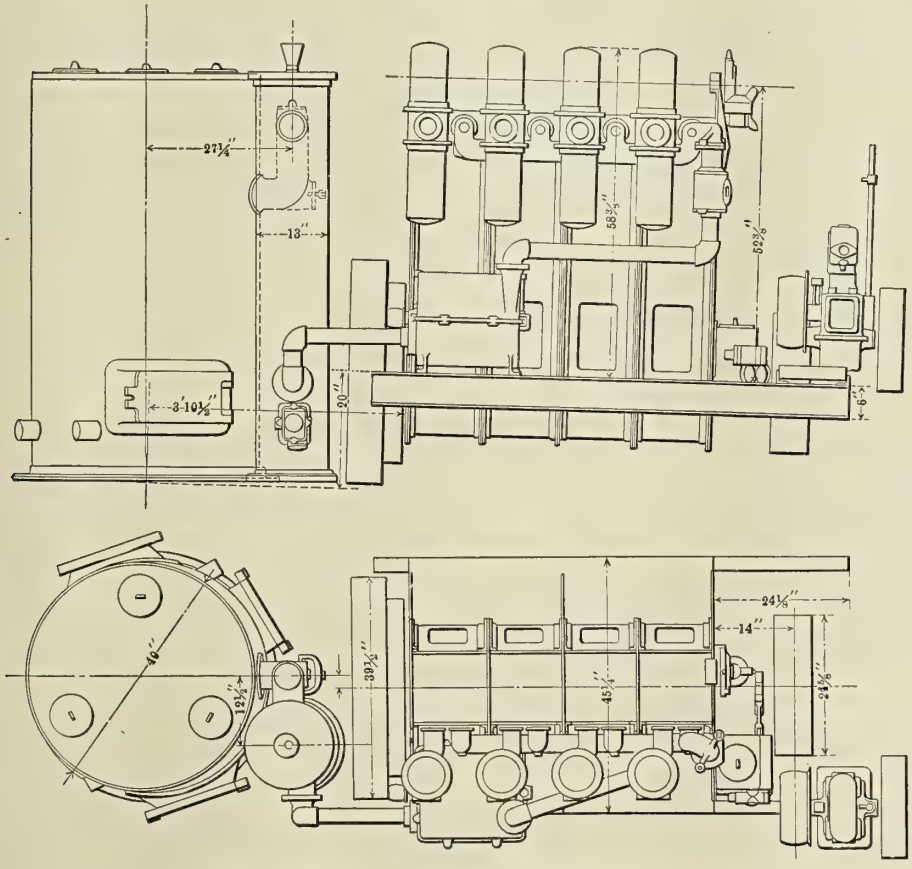
THE SUCTION PRODUCER GAS VESSEL DALMUIR, PROFILE AND DECK PLAN.

A Suction Gas Producer Vessel.

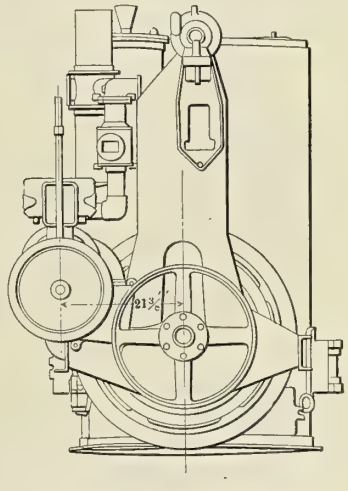
Messrs. William Beardmore & Co., Limited, Dalmuir, Clyde, who are jointly interested with Messrs. Thornycroft in working the Capitaine gas production system, have brought out the launch *Dalmuir*, which is the first vessel built in Scotland pro-

Either coke or anthracite coal may be burnt in the producer, and the gas is generated from a mixture of air and steam drawn through the incandescent fuel by the partial vacuum created by the outstroke of the piston in the engine.

The whole producer plant working at a pressure below that



ENGINE AND PRODUCER OF DALMUIR, SIDE ELEVATION AND PLAN.



END VIEW OF PLANT.

of the atmosphere, there is no chance of leakage of gas. Gas is produced only as it is needed by the engine, and in quantities to suit the varying loads, so that there is no waste while the engine stands idle. As no gas holder is necessary, there is no danger of explosion. A small floor space is ample.

The heat efficiency of this plant compares favorably with that of the very best compound condensing steam engine; being 23 percent, as compared with only 11 percent for the steam engine. That is to say, the gas plant consumes less than one-half the fuel which would be used in a steam boiler and engine of the same power.

A fair average consumption for different qualities of coal is 1 pound of fuel per brake horsepower per hour. If good anthracite be used, this figure may be slightly reduced. If the fuel be coke the consumption will be about 1¼ pounds.

The engine of the *Dalmuir* is one of the four-cylinder type, 60 horsepower, 240 to 360 revolutions per minute. The plant weighs 9,950 pounds and the propeller weighs 870 pounds. The dimensions of the plant are: 8 feet 3 inches by 3 feet 9 inches by 6 feet high. The drawings display the whole design of the vessel.

This gas engine launch is peculiarly interesting because it is a practical demonstration in miniature of a larger operation which Messrs. Beardmore have on hand, that may serve to revolutionize marine locomotion. They are just completing for a cargo vessel a single acting gas engine 20 by 24 inches. This engine has five cylinders, each section complete in itself, and so arranged that one, two, three, four or all sets may be operated. The crank is solid built, and there is reversing gear. This engine is to develop from 500 to 600 horsepower, and is to be fitted on board of a "steamer" that has been run for some years with ordinary reciprocating engines, so that a complete comparison may be made with previous records. The gas suction plant for this engine is of the same type as that on the *Dalmuir*, and is fitted to consume any quality of bituminous coal (not necessarily anthracite, which is dear in Great Britain), automatically fed. The vessel to be fitted with this engine will be at work in the course of the early summer, and she will be the first commercial vessel in this country propelled by internally produced gas.

Benjamin Taylor.

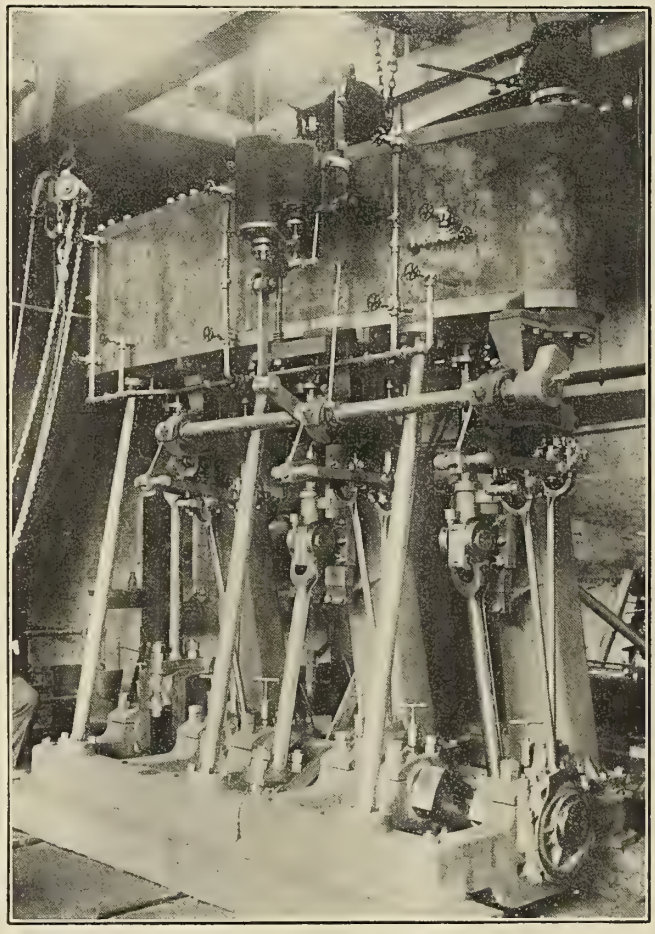
THE NEW PASSENGER STEAMER MAYWOOD.

A 600-HORSEPOWER TRIPLE EXPANSION MARINE ENGINE.

This engine was built by the Marine Iron Works, of Chicago, for the steamer *Maywood*, of the Escanaba and Gladstone Transportation Company.

The high and intermediate cylinders have ring fitted balanced piston valves, and the low-pressure double ported slide valves. Each cylinder and its valve chest are cast separate of semi-steel. Cylinders are well lagged with magnesia and jacketed. The pistons are of the dished type and made of cast steel. Piston rods are of steel, turned, ground and polished; crossheads of steel fitted with bronze boxes.

The cylinders are supported at the back by three hollow cast iron columns, to which are fitted hollow cast iron "bar" guides for the crossheads, the front framing consisting of three forged and turned steel columns. The forged connecting rods are forked at their upper ends and fitted with tapered, shouldered



600-HORSEPOWER ENGINE OF MAYWOOD.

and case-hardened crosshead pins; crank-ends are fitted with bronze boxes.

Each valve stem guide is cast in one piece with the stuffing box and rocker-shaft bearing.

The valve gear is of the Stephenson type, fitted with double bar links; reversing by steam cylinder connected direct to rocker-shaft arm, with independent adjustable cutoff to each valve. Eccentric rods have "T" heads at eccentric end, being forked at the top to span the link, and are fitted with bronze bearings.

The engine illustrated is of the following dimensions:

High-pressure, 14 inches diameter.

Intermediate, 22 inches diameter.

Low-pressure, 36 inches diameter.

Stroke, 24 inches.

The crank shaft is slotted out from a solid steel forging, the cranks being set at an angle of 120 degrees, the dimensions of crank-shaft being proportioned to the steam pressure and service.

The bed-plate is cast in one piece, having six pedestal bearings, each being fitted with bronze boxes lined with white metal.

The most approved "takeup" attachments are fitted to valve stem guides, link blocks, crosshead and crank brasses, etc.

The cylinders and valves are lubricated by sight feed oil pump operated by trip and rod connection to engine. Multiple box oilers with outside drop supply the crosshead guides, crosshead and wristpins; crank-shaft bearings are served by extra large compression grease cups; other parts, such as eccentric straps, etc., are fitted with oil and grease cups.

All the moving parts are closely counter-balanced, as demonstrated by the absence of vibration when the engine is driven at various speeds.

The *Maywood* has a length over all of 142 feet, a length on the keel of 130 feet, a beam of 25 feet and a depth of 10 feet 6 inches. Her gross tonnage is 398 and net tonnage 309. She has state room accommodations for fifty passengers, and excursion capacity for 450. In the hold forward and on the forward deck is a small space for cargo stowage. The dining room is on the main deck aft, above which, on the cabin deck, is a large covered promenade space. The vessel was built by the Manitowoc (Wis.) Dry Dock Company.

A Modern Dry Dock in Greece.

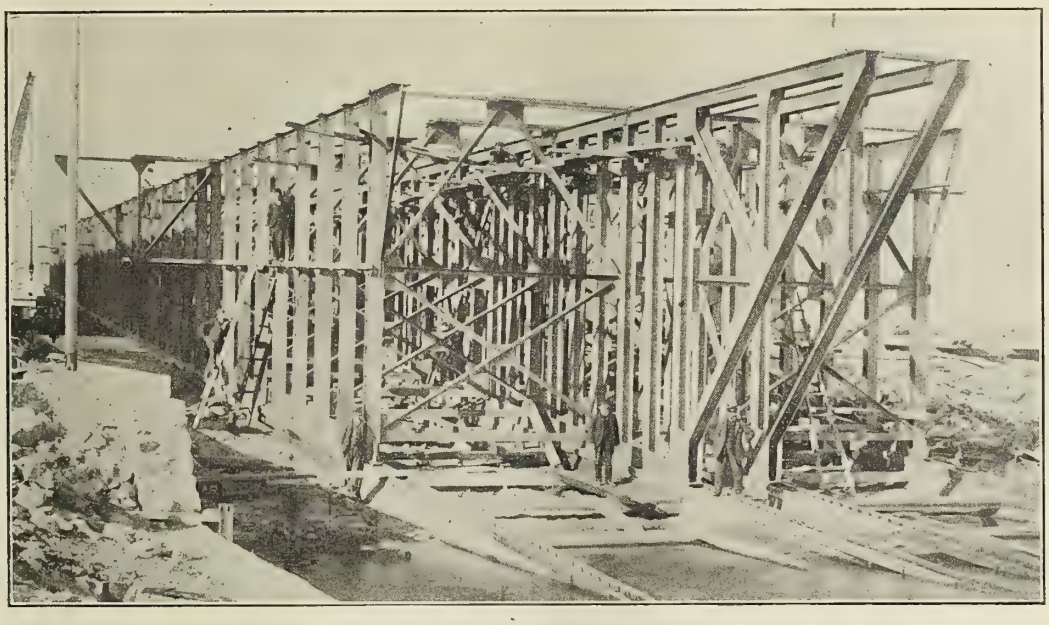
We illustrate a construction view of the aft built-up portion of a Crandall type of railway dry dock, constructed at Piraeus, Greece, for the Ateliers et Chantiers Helleniques "Basilades."

This dock has a capacity for docking a vessel of 4,000 tons dead weight. It is constructed of steel for the under body (as partly shown in illustration) with heavy timber cross beams resting upon the columns, and is decked over completely, with the exception of a space under the keel-blocks of 4 feet in width, purposely left open to facilitate repairs to ships' keels. A docking platform extends nearly the length of the dock on each side, from which are operated, by galvanized chains and geared winches attached to the uprights supporting the platforms, thirty-eight releasing bilge-blocks. The dock rests upon four tracks, which in turn are supported on concrete foundations, and is operated by electric power through a train of gears and six special long link chains attached to the dock by a patent equalizing gear, which absolutely equalizes the pull on each chain. The time required to haul, completely up, a vessel of 4000 tons, after it has been centered, ranges from 30 to 35 minutes. Quicker time can be made on smaller loads by using the fast gear. The roominess of the deck, the free access of light and air about the ship's bottom and the ease with which material may be placed at any desired point where it is most required, on account of there being no sides, greatly add to the efficiency of repairing vessels.

The following dimensions may be of interest:

Capacity—dead weight	4000 tons
Length on keel-blocks	336 feet
" " deck	356 "
Width over cross-beams	68 "
" between docking platforms	62 "
Depth of water over aft keel-blocks—dock down	20 "
Number of tracks	4
Grade of tracks	1:12
Distance of keel-block centers	4 "
" " bilge-block centers	12 "
Time of hauling full loads	35 minutes

This dry dock has recently been built by the H. I. Crandall & Son Co., East Boston, Mass.



STEEL FRAMEWORK OF RAILWAY DRY DOCK AT PIRAEUS, GREECE.

MARINE TURBINES IN SERVICE.

BY ROBERT S. RILEY.

With most engineers, not directly associated with turbines, the idea prevails that once a turbine is set up and running that is about all there is to it—that is, it has no individuality such as a reciprocating engine has, for everyone knows that a reciprocating engine has numerous personalities peculiar to itself. Some engines give trouble with the valve gear, others in the guides; another may have a pet crank pin that requires special attention, and so on to a legion of more or less important details, which every engineer has to study for each engine of which he takes charge.

It is true that the running part of a turbine consists simply of a revolving rotor. But there are other moving parts. In fact, with the refinement of clearances due to this method of using steam, almost every part of the entire turbine has to be considered a moving part, with a motion of its own. Contraction and expansion measure the extent of this movement, and any change of temperature supplies the necessary motive power. It will be seen, therefore, that this opens up a world of personalities in a turbine, which may be fully as complex as the vagaries of a quadruple expansion reciprocating engine. Every engineer knows that the behavior of an engine will vary with the speed, sometimes valve-gear and piston rods giving more trouble at low speed than at high. These peculiarities of a

reciprocating engine have been the subject of careful study, and long experience has shown how to provide for them. Besides this, the big high speed engines have been through such a process of evolution that each change or addition has not been very radical.

However, in the case of the turbine, designers have been forced at once into competition with reciprocating engines that have been the product of years of study to get them to their present size and efficiency. Naturally this results in some crudities, which experience and study may eliminate. To a certain extent, therefore, all turbines built are experimental as yet, but each gets nearer the future standard, and adds its quota to the general fund of information. Not that a turbine built today may become obsolete a few years hence; the general principles are established and will not change, but many details will. It is not probable, for instance, that old turbines will be displaced as old automobiles have been, for the latter are more or less of an undeveloped commodity, and their use gives rise to more notions each day; whereas the mission of the turbine is pretty clearly defined. It is to take the place of high-speed reciprocating engines, and do the work that they have done so completely for years.

There are now quite a number of sea-going turbine engineers, practically all of whom are in charge of Parsons turbines, as this is the only type as yet in general use on board ship. Talking over troubles and peculiarities with these men brings out the fact that there is a good deal more to be looked after than is generally supposed. For one thing the speeds are high and lubrication correspondingly more important. The two main bearings of each turbine are kept floating in oil under pressure. This is very essential, for if ever the metals should come into intimate contact without a film of oil interposed, the friction would soon be fatal. This has occured in one turbine job, with the result that the metal promptly melted, the alignment was thrown out, the blades of the rotor fouled those of the stator, and hundreds of them were stripped. This happened on the American coast, and an expert blader had to be sent from England to fit new blades.

This forced lubrication is therefore an added responsibility for the engineer, as it involves another complete system. The larger ships have this in duplicate, so great is its importance. But perhaps the greatest additional care required in lubrication come in the shaft alley. The forced lubrication takes care of the turbine bearings proper, but thus far has not been extended to the spring bearings. These bearings are generally a source of considerable anxiety. Water has to be used freely, and even then the temperatures are excessive.

It is a good thing that the line shafts can be made so much lighter and still transmit the same power as a slower speeded shaft. This off-sets, to some extent, the tendency of a shaft to heat, due to its own weight and rigidity in resisting motions of the ship.

One bearing, however, may be excepted from the general tendency to givem ore trouble than the reciprocating engine's, and that is the thrust. Here is an ideal condition, where the thrust of the propeller on the water is directly opposed by the thrust of the steam on the forward sides of the blades of the rotor. Conversely, when going astern, the pull of the propeller is opposed by the forward pressure of the steam on the go-astern blades.

The auxiliary machinery for circulating and air pumps is much larger than would be required with a corresponding set of reciprocating engines. This is due to the great importance of high vacuum in the economy of the turbine. The addition of intensifiers, or of dry air pumps, further complicates the engine room equipment. The intensifier is practically another small condenser for a steam siphon which increases the vacuum in the main condenser. This additional vacuum is held in the main condenser by means of a differential water seal in the pipe connecting the two condensers. The dry air pumps are likely to be finer pieces of machinery than ordinary air pumps. Their valves are positively driven, instead of automatically.

We hear a good deal of the successful working of the turbine, and very little of its troubles. Nevertheless the latter occur. Sometimes the most trivial change in normal conditions causes an abnormal contraction or expansion, and the blades foul. For instance, one steamer had been in successful operation for over two years; the low pressure turbines had been running "dead slow" in a fog for one hour, longer than they had ever been before, so that they were running on cold vapor, and were quite cold from end to end. An order came for "full speed astern". The rush of hot steam through the astern blades of the rotor shell caused a sudden expansion, and blades that had cleared for two years, fouled and wrecked themselves, putting one turbine out of commission instantly, though nothing appeared on the outside to indicate anything wrong.

Another case occured on a liner which had run successfully for some months. The propellers were changed from four to three bladed, with consequent speeding up of the turbines above the designed speed. In setting a governor, it is supposed that one low-pressure turbine ran a few revolutions above the maximum allowed. The construction of the rotor drum was such that the butt straps holding together the plates of which it was composed, formed a powerful moment under the action of centrifugal force. The circumference of the shell was distorted, and the blades touched and were stripped.

As an off-set to the liability of injury to the blades it may be said that turbines run practically as well with a large number removed. Thus, in the two cases just cited, the covers were lifted at the first opportunity and the stripped blades removed from casing and rotor. It was impractical to re-blade them at the time, so the casings were replaced with the blades missing. No serious difference was noticed, and each ship did its duty until an opportunity arrived for re-blading.

An interesting case of this kind happened recently in a stationary plant. A large number of blades were stripped; the casing and rotor were lifted immediately, and the stripped blades removed. The turbine was started again and ran continuously, each working day, without further trouble. Each night the cover and rotor were lifted and a ring or two of blades inserted until they were all complete again. It is doubtful if any job of similar magnitude could be done in instalments thus on a reciprocating engine.

Most men in charge of turbines claim that it is a "chief engineer's job"; that is, the final responsibility rests on one man, and he cannot delegate it to the same extent that can be done with a reciprocating engine. There is no chance to "take leads" to bring up and show the chief how things are running. If he has reason to question the clearance of blades anywhere, he must spend anxious minutes with his ear on the casing, while the turbine is speeded up cautiously, listening intently for the faintest sound of interference. Adjustments can be made to allow for the wearing down of the main bearings, but this is very seldom required with perfect lubrication. Each case of adjustment calls for renewed careful listening and cautious speeding up, for once a blade touches strongly enough to bend it, they all go down like nine pins, and a "ten strike" is easily made.

An obstruction accidently left in the casing would mean ruin to the blades, if it were swept into them by the rush of steam. Even a small piece of waste, or an overall button would be sufficient to start a "ten strike". As these casings at the condenser end are sometimes large caverns into which men go for observation, it will be seen that the man responsible will be pretty careful not to let anything drop or be left behind by mistake.

Taking it all together, however, the turbine men are agreed that they would rather take care of a turbine than almost any reciprocating engine. There are fewer details to worry about, and those that do give trouble are apt to be strictly "up to" the designer, rather than to the operating engineer.

Probably the method of fastening the blades is the most critical point at present. Great improvements have been made however, and it is likely that the problem will soon be satisfactorily solved. It is all expert work, and the average operating engineer is not likely to have much to do with it. Experience will probably develop the art to such an extent that stripped blades will be very rare. The clearance spaces are already considered of less moment than formerly, and this relieves much of the danger of fouling. Improved facilities for finishing the ends of the blades or shroud rings will leave them less liable to fouling. There is also quite an art in the design of casings so that they will not change form too radically upon the application of heat.

As regards the handling and maneuvering of the turbine, it is much simpler and less hazardous than with reciprocating engines. There are no drains which, if forgotten, might knock out a cylinder head. The time required for "warming up" is much less, for steam has access to all parts at once. This, of course, is of great advantage when standing by for departure or "up anchor." The high-pressure turbine, in the prevailing arrangement of three turbines, is not touched at all in maneuvering or getting away, and it is the first to be shut off on an arrival "stand by." Sometimes this turbine has no separate telegraph control for taking orders from the bridge, the engineer simply turning it on when he gets his jingle for right away. When fitted with a telegraph there are no "go astern" signals, of course, and such a telegraph dial looks odd at first sight.

The low pressure turbines are the only ones fitted with reversing blades, and so, of course, are the only ones worked to bells. Their operation is very simple, for the levers are arranged so that the cut off from the high pressure turbine is automatic. When maneuvering, the engineer has to depend on the governor balls to show when the turbine moves, for there is nothing visible to correspond with the numerous moving parts of the reciprocating engine. The turbines start quite promptly on the inlet of steam, and soon speed up. The regulation of speed according to orders is done by maintaining given pressures in the steam pipes. When shut off, the turbines do not stop so promptly, for the inertia carries them around until overcome by friction. For a quick stop the steam is turned into the astern side to help bring up the turbines. In case of a sudden order from "full ahead" to "full astern," the steam is instantly switched from the ahead to the astern blades, with no thought of the racking that would occur to reciprocating engines if they were treated thus. The turbines soon bring up under such treatment and in a few seconds are running just as fast astern. The smaller propellers, of course, are not so hard to reverse as would be the larger ones of a reciprocating engine, and, conversely, do not take such a grip on the water. That is, they start a column of water in movement promptly enough, but it is not of large diameter, and is not so quickly felt by the ship.

Much attention is being paid to this reversing feature of the turbine propeller. Recent turbines are built with almost as many go astern blades as they have on the go ahead side. They are on a smaller radius, the expansion is not so complete, but they use high pressure steam and the power is there, even if not quite so efficient. The result is that turbine ships can now stop about as quickly as any other. For maneuvering it must also be borne in mind that the turbine propellers are set away out from the center line of the ship. This gives a greater turning moment in case of swinging the ship about.

There are arguments on both sides of this turbine question, all of which may appeal differently to different engineers. Here is about the way they line up to the men who run them:

ADVANTAGES.

More room in the engine room, especially head room.

No moving parts exposed. Consequently no danger of getting caught, due either to lack of care, or to accident, and no oil thrown around.

No vibration of the ship, hence pipe hangers, joints, etc., do not shake loose.

Lighter shafting in engine and alleys.

Balanced thrust; smaller bearing and less heating of same.

Foundations of the engine lighter and more accessible.

No oil carried through to boilers, and oil saved due to increased efficiency of application.

No danger due to foaming or priming of boilers.

Less attendance required on engines, nearly everything being automatic.

Better immersion of smaller propellers, hence no racing in a sea way.

Less steam pressure. High vacuum is easier and more comfortable to handle than high steam.

Turbines easily turned when cold, and less likely to need it.

DISADVANTAGES.

Moving parts not accessible and not visible, so you don't know what is going on inside.

Auxiliary machinery larger and more important, hence more care.

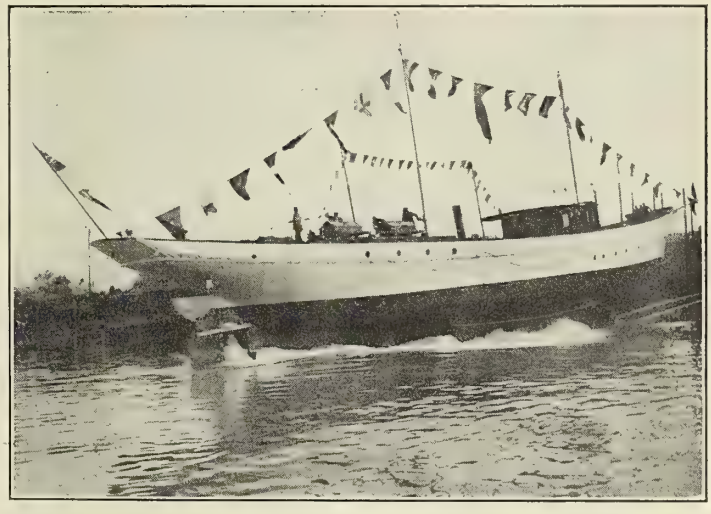
More dependence on automatic lubricating system for bearings.

At least one more line shaft to care for, and all of them at higher speed and more apt to run hot.

Main casings and rotor very heavy to handle, and great care required even with best appliances on new ships.

Danger of disablement by unseen causes among the blades.

Difficulty in making repairs to blades.



THE LAUNCHING OF STEAM YACHT BRANWEN.

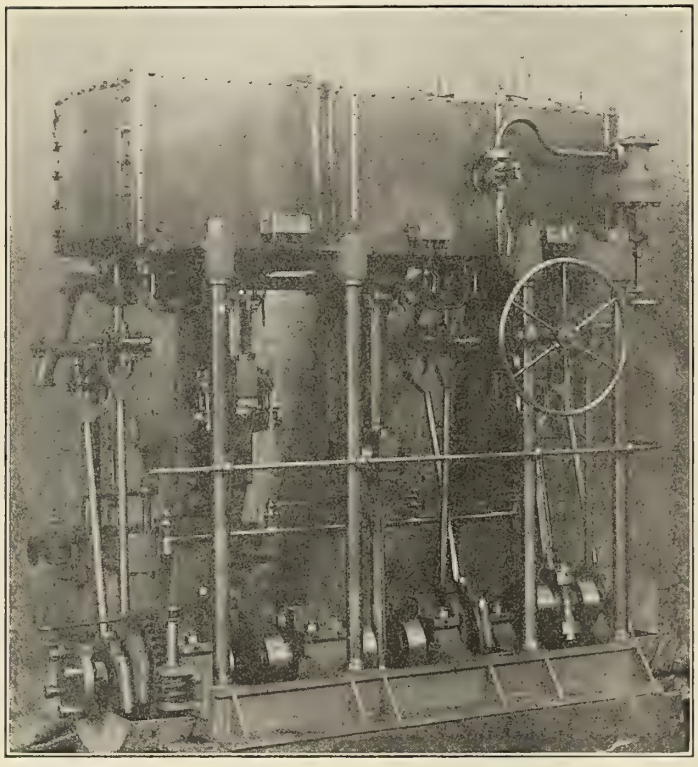
THE STEAM YACHT BRANWEN.

For Lord Howard de Walden, the English shipbuilders J. I. Thornycroft and Company launched recently the steam yacht *Branwen*, the first built at their new Woolston (Southampton) Works. The principal dimensions of this yacht, which has been constructed to Lloyd's highest class and under special survey, are as follows:

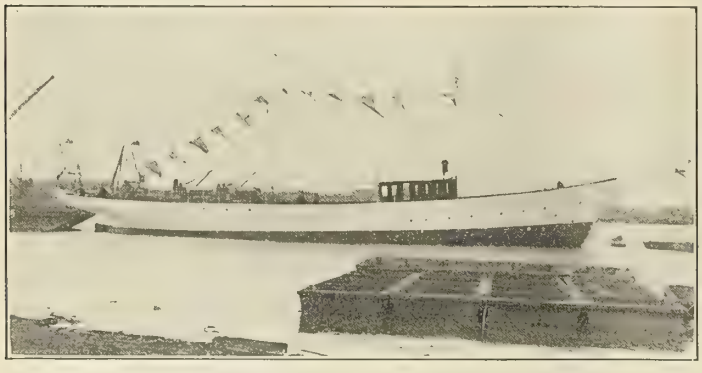
Length over all	135	feet	0	inches
Length between perpendiculars	111	"	6	"
Length on load water line	108	"	0	"
Breadth molded	16	"	6	"
Depth	11	"	3	"

The yacht is of steel with handsome scroll figurehead and trail board, quarter badges, etc; the design being oak leaves and acorns in relief and embodying the owner's armorial bearings. She is rigged as a fore-and-aft schooner with two pole masts.

The machinery is situated amidships, and consists of a triple-expansion condensing engine, having cylinders 9, 15 and 25 inches in diameter with a stroke of 18 inches, and a cylindrical multi-tubular return tube boiler, having an inside diameter of 9 feet 7 inches, and a length of 8 feet 9 inches. It is constructed for a working pressure of 180 pounds per square inch, to Lloyd's requirements.



THE TRIPLE EXPANSION VERTICAL ENGINE.

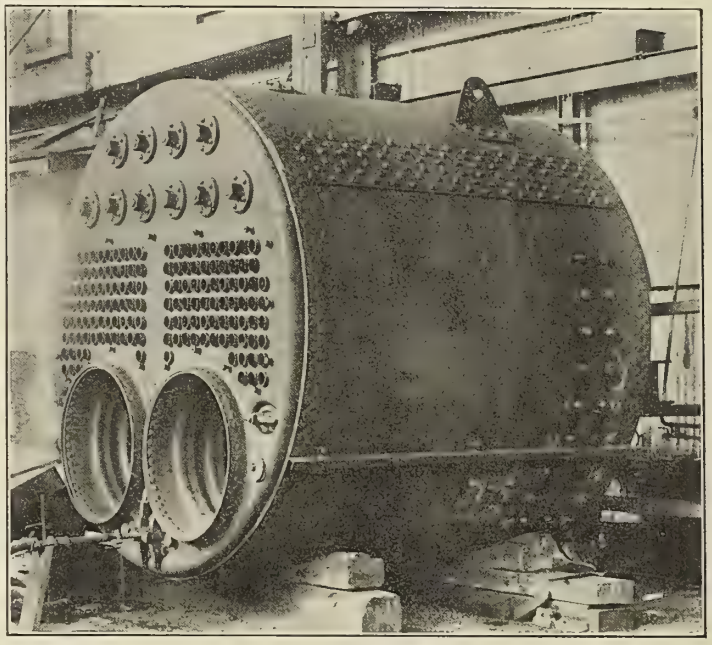


THE YACHT AFLOAT, JUST AFTER LAUNCHING.

The decks and all skylights and fittings are of teak. A teak deck-house is situated at the fore end of the machinery space, and is arranged as a smoking room, a companion stair communicating with the accommodation below. The after end of the deck-house forms a bridge deck, from which the vessel will be steered by means of steam steering gear. An awning is arranged to be fitted over the raised deck.

The accommodation aft is entered by a sliding companion and ladder-way down to a roomy vestibule, with seats fitted up on either side, and with a door leading to the main saloon, which extends across the vessel. On the fore side of the saloon, and entered from same, is a lobby, with lavatory and bath room accommodation, and forward of this are two state rooms.

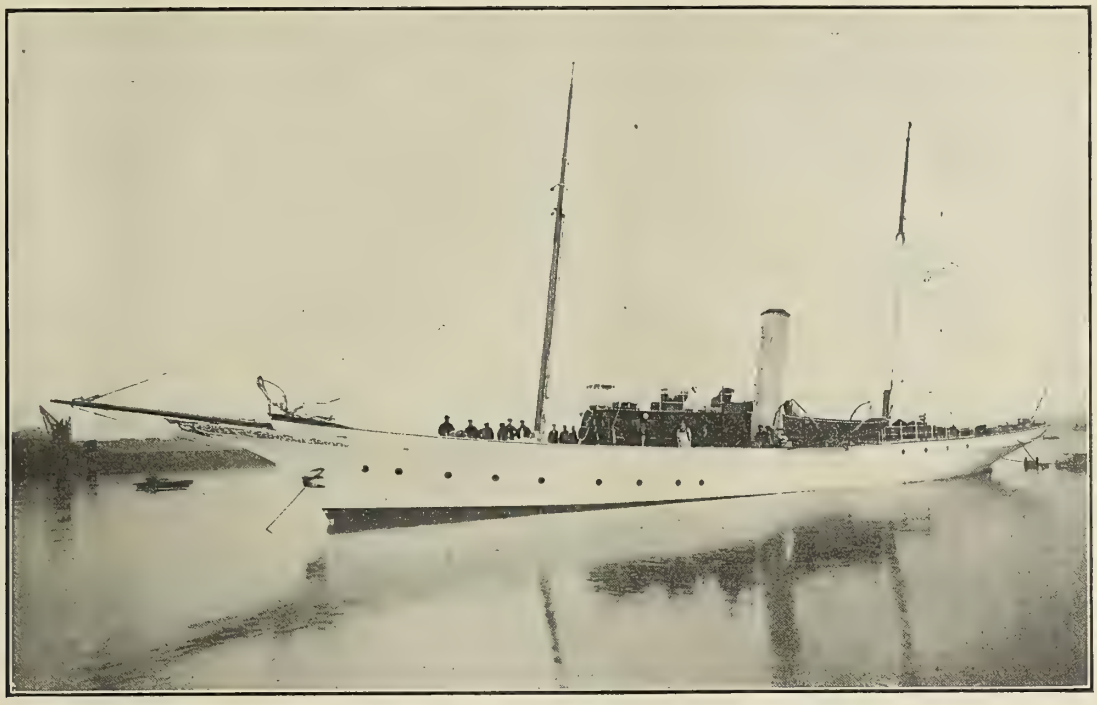
The forward accommodation consists of a deck saloon before mentioned, the stairway in same leading directly into the dining saloon below, which extends across the vessel. Abaft the saloon is the pantry on port side, and a bath room on starboard side. On the fore side of the dining saloon are two state rooms. This comprises the owner's accommodation. The after vestibule will be paneled in teak, the after lobby in light oak, and the remainder of the owner's accommodation enameled in white. The crew are berthed forward in the forecastle, with captain's and engineer's cabin abaft same.



THE TWO-FURNACE SCOTCH BOILER.

THE OWNER'S STATEROOM, STEAM YACHT BRANWEN.

Fresh water tanks to hold 500 gallons of water are arranged forward and aft, with connections to pantry and galley. A hot water tank is fitted inside boiler casing to supply baths and lavatories, and a drain tank is fitted aft to take the waste water from



THE NEW STEAM YACHT BRANWEN, AT ANCHOR IN THE SOLENT.

pantry, baths and lavatories. The yacht will be heated throughout by steam, with radiators in the principal cabins. Two boats are to be carried in davits, a 20-foot gig, and a 16-foot cutter. Occasionally a 14-foot motor launch will be carried in place of the cutter. A steam capstan for working the cables, and warping the yacht is fitted forward.

THE BATTLESHIP NEW HAMPSHIRE AFLOAT, AFTER BEING LAUNCHED INTO THE DELAWARE.

LAUNCH OF UNITED STATES BATTLESHIP NEW HAMPSHIRE.

On June 30 the battleship *New Hampshire,* under construction at the yard of the New York Shipbuilding Company, Camden, N. J., was successfully launched. The ship has a length of 450 feet, a beam of 76 feet 10 inches, and with a draft of 24 feet 6 inches will have a trial displacement of 16,000 tons.

Propulsion is by twin screws actuated by two four-cylinder triple expansion engines of a combined indicated horsepower of 16,500, the corresponding speed being 18 knots. The cylinder diameters are 32½, 53 and two of 61 inches, with a common stroke of 48 inches. Steam is supplied by a battery of twelve Babcock and Wilcox boilers, at a pressure of 250 pounds per square inch. The normal coal supply of 900 tons can be augmented to a full bunker capacity of 2,325 tons.

The battery is a very powerful one, including four 12-inch rifles in pairs in turrets on the center line forward and aft; eight 8-inch rifles in pairs in turrets on the broadside; and twelve 7-inch rapid-fire guns in an armored casemate. The secondary battery includes twenty 3-inch rapid-fire guns and twenty-two smaller pieces, besides four 21-inch submerged torpedo tubes.

The armor includes a water line belt 9 inches thick, heavy barbettes with a maximum thickness of 11 inches, reduced to 7½ and 6 inches where protected by side armor; 8-inch barbettes with a thickness of 6 inches in the front and 4 in the rear; heavy turrets 12 inches thick in front and 8 in the rear; 8-inch turrets with thickness of 6½ and 6 inches. The protective deck, extending the full length, is 3 inches thick forward and aft, and amidships the slopes are 3 inches thick and flats 1½ inches.

The act authorizing the construction of the *New Hampshire* was approved April 27, 1904, and the contract was awarded December 27, 1904, the price being $3,748,000, this figure

covering hull and machinery. The keel was laid May 1, 1905, and the contract calls for completion February 27, 1908. The complement includes 41 officers and 840 men.

The *New Hampshire* is a sister ship to the *Minnesota, Louisiana, Connecticut, Kansas* and *Vermont.* Descriptions and illustrations of these ships will be found at pages 450, October, 1904; 489, November, 1904; 251, June, 1905; 429, October, 1905; and 165, June, 1906.

Errors in Naval Engineering Calculations.

BY CAPTAIN A. TROMP.

In comparing ships of different navies, very frequently—rather too frequently—errors are made; some of which, at the request of the Editor of International Marine Engineering, I will point out:

Horsepower.—One English horsepower = 1.01389 metric horsepower; or one metric horsepower = 0.9863 English horsepower. The result of this difference is that the transfer of a coal consumption of say 1 pound per English horsepower to metric weight, cannot be based on the fact that 1 pound = 454 grammes. It is more—1 English pound per English horsepower = 460 grammes per metric horsepower. Very often 500 grammes are taken. So, for instance, on page 351 of Vol. XVI., *Journal American Society of Naval Engineers,* the consumption of the *Amiral Aube* per unit of power was given as 588 grammes (1.17 pounds), whereas it ought to be 1.28 pounds. The limits were 1.63 to 1.74, and not 1.5 to 1.6 pounds.

The table on page 460 of the same volume is based on 1 pound to 447 grammes; therefore, the coal consumption in pounds is given too high.

Displacement.—One English ton = 1.0162 metric ton; or 1 metric ton = 0.9842 English ton. This difference has to be taken into consideration in calculating certain coefficients of fineness.

Length Between Perpendiculars.—English perpendiculars are entirely different from American and also from French. In the United States and French navies the after perpendicular goes through the intersection of the ship's hull with the water-line. The forward perpendicular in the United States Navy goes through the intersection of the sheer with the water-line, as against in the French Navy through the point of the ram. In the English and most of the other navies the forward perpendicular is taken as in the United States Navy, but the after perpendicular goes through the stern post; in other words, it defines the real under-water body of the ship.

In order to make a fair comparison between ships, it is evident that everything has to be based on the same standards. According to the American principle of perpendiculars, the ratio between length and beam in the *Colorado* and *Washington* are respectively 7.22 and 6.89. The English *Devonshire* and *Duke of Edinburgh* have a ratio of respectively 6.56 and 6.53; but applying the English principle to the American ships the ratios in the latter would be 6.99 and 6.67.

For the French Navy, very high ratios may be found, but brought back to the English principle they do not show anything extraordinary.

	American Perpend.	French Perpend.	English Perpend.
Colorado	7.22	...	6.99
Washington	6.89	...	6.67
Devonshire	...	...	6.56
Duke of Edinburgh	...	...	6.53
Jeanne d'Arc	...	7.50	7.09
Dupleix	...	7.30	6.94
Condé	...	6.83	6.58
Leon Gambetta	...	6.85	6.61
Ernest Renan	...	7.30	7.02

It is, therefore, evident that ship data as found in the usual handbooks, like *Brassey, Jane, Clowes, Durassier,* etc., are misleading, and they are the more misleading when they are used for figuring out certain coefficients of fineness.

Coefficients of Fineness.—Even assuming that all data about ships are based on the same standards, the usual coefficients of fineness do not furnish a basis of comparison. They are absolutely misleading. I know only one coefficient which gives a good idea of the under-water form of the ship. The formula is: $\frac{\text{Beam}}{\text{Length}} \times$ Cylindrical coefficient of fineness. I will illustrate this with the following coefficients.

	Block.	Midship.	Cylindrical.	$\frac{B}{L} \times$ Cyl.
Colorado	.5883	.9535	.6170	0.0883
Washington	.5732	.9507	.6029	0.0904
Jeanne d'Arc	.5478	.8223	.6661	0.0940
Dupleix	.4842	.7782	.6223	0.0897
Condé	.5190	.8399	.6179	0.0939
Leon Gambetta.	.5246	.8565	.6125	0.0926
Ernest Renan	.5193	.8573	.6058	0.0863

CHECKING OFF DATA FROM EVAPORATION TESTS.

The following formula is of practical use for checking off data from evaporation tests of boilers:

When A = ratio of heating surface to grate surface,

B = pounds of water evaporated per hour per square foot of heating surface,

C = pounds of coal burned per hour per square foot of grate surface,

D = pounds of water evaporated per pound of coal burned,

then $A \times B$ must equal $C \times D$, because:

$$\frac{H.S.}{G.S.} \times \frac{\text{Water per hour}}{H.S.} = \frac{\text{Coal per hour}}{G.S.} \times \frac{\text{Water per hour}}{\text{Coal per hour}}$$

or,

$$\frac{\text{Water per hour}}{G.S.} = \frac{\text{Water per hour}}{G.S.}.$$

The usefulness of this formula can be demonstrated by the following data:

Niclausse Boiler (1904 Report, Bureau of Steam Engineering, U. S. N.). Test No. 1 (page 922),

$$A \times B = 40.96 \times 6.27 = 256.82,$$
$$C \times D = 20.8 \times 12.41 = 258.13.$$

Now C was not = 20.8, but 20.7, and now we get $C \times D = 256.87$, which checks with $A \times B$.

Babcock and Wilcox Boiler (1904 Report, Bureau of Steam Engineering). Test No. 4 (page 910),

$$A \times B = 41.91 \times 7.85 = 329.00,$$
$$C \times D = 28.56 \times 11.09 = 316.73.$$

Now B was not = 7.85, but 7.56, and now we get $A \times B = 316.67$, again checking with $C \times D$.

A mistake has been made in line 46, which is line 44 divided by line 2, or 283,031 ÷ 8 = 35,378, and not 35,125. Even with this figure of 35,125, the 7.85 is a mistake, as 35,125 ÷ 4,682 = 7.50.

Babcock (Cincinnati) Boiler (Babcock and Wilcox Handbook). Test No. 9,

$$A \times B = 41.74 \times 6.47 = 270.06,$$
$$C \times D = 20.72 \times 12.22 = 253.20,$$

but B = 6.07 instead of 6.47, and now we get $A \times B = 253.17$.

Test No. 8,

$$A \times B = 41.74 \times 9.43 = 393.6,$$
$$C \times D = 34.03 \times 11.45 = 389.65,$$

but D = 11.57 instead of 11.45, and now we get $C \times D = 393.65$.

Test No. 4,

$$A \times B = 41.74 \times 8.75 = 365.23,$$

$C \times D = 32.18 \times 11.5 = 370.00$,

but $C = 31.75$ instead of 32.18, and now we get $C \times D = 365.10$.

The above tests are based on combustible, equivalent evaporation from and at 212 degrees, etc.; but we can also take B' = pounds of water fed to boiler per hour per square foot of heating surface, C' = pounds of coal fired per hour per square foot of grate surface, D' = pounds of water as fed to boiler per pound of coal as fired; in other words, data which can be obtained in the regular service, doing away with analysis of coal, quality of steam, and factor of evaporation.

For instance, among the twelve evaporation tests made in December, 1903, under such circumstances, on board the Dutch armored ship *Hertog Hendrik*, I found one which gives $D' = 7.82$, whereby 259.71 is equated to 279.97, but 13,976.7 pounds of water divided by 1,926.84 pounds of coal = 7.254, and now we get 259.71 = 259.71.

One more and rather striking example:

Belleville (*Hyacinth*) *Boiler* (Naval Progress, No. XXI., page 289).

The 8,000-horsepower and the full-power trials were said to have given the following data (Ratio, 30.88 = *A*.):

B	*C*	*D*	*AB*	*CD*
6.38	19.8	9.39	197.04	185.93
7.78	27.2	8.28	240.25	225.21

Here the data of water per pound of coal are absolutely wrong, for:

147,190 water ÷ 14,930 coal = 9,859, and not 9.39,

190,210 water ÷ 21,515 coal = 8.840, and not 8.28.

Also, figuring out the other data more correctly, we now get:

6.380	19.99	9.859	197.04 = 197.04.
7.787	27.20	8.840	240.47 = 240.47.

This formula, therefore, gives a simple means for discovering arithmetical errors in evaporation data, and that it is needed is proved by the facts mentioned above.

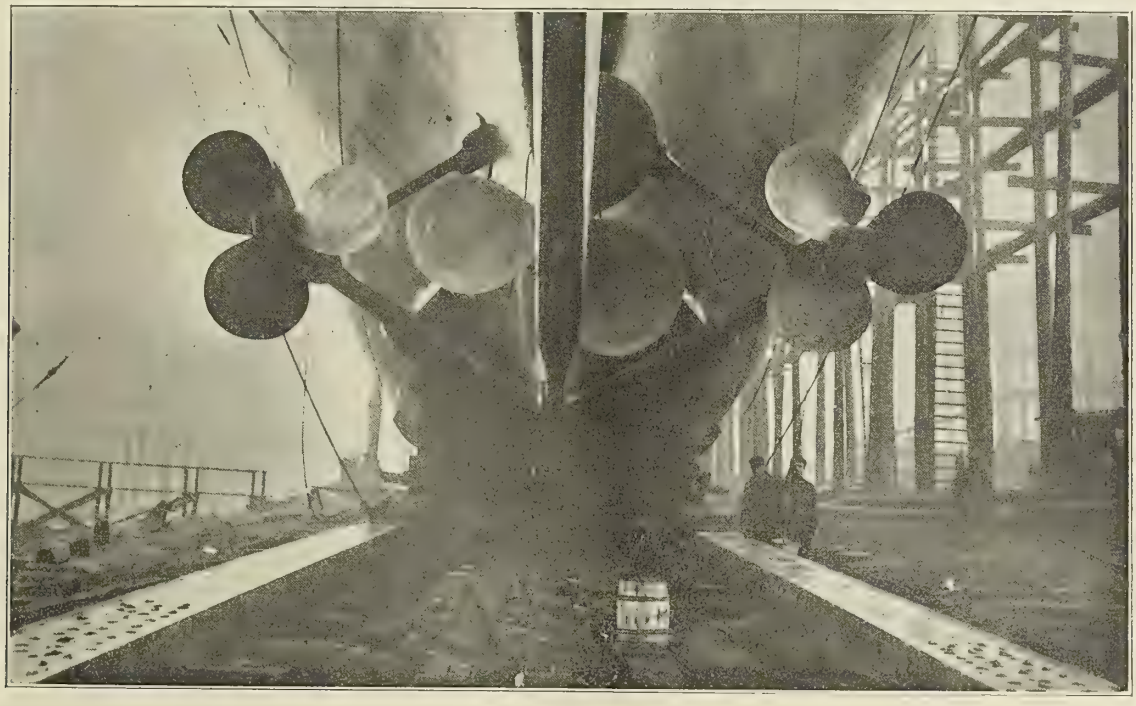
LAUNCH OF TURBINE STEAMER "VIPER."

BY ALLAN M'PHERSON.

The Fairfield Shipbuilding and Engineering Company of Glasgow launched from their yard on March 10 the steamer *Viper*, the first turbine vessel built for the Irish Channel service. With the advent of this fast steamer, the time occupied in the journey between Scotland and the popular tourist resorts in Ireland will be considerably reduced. The *Viper* will take the place of the paddle steamer *Adder* in the daylight service between Ardrossan and Belfast. The adoption of turbines in the *Viper* goes to show that this type of engine has been proved to be the most efficient for high speed traffic, and in addition the most comfortable for the traveling public, as it reduces vibration to a minimum.

The new steamer will be unequalled on any cross channel service in the kingdom. She is guaranteed to maintain a speed on service of 21 knots, and is of the following dimensions:

Length between perpendiculars	315 feet 0 inches
Breadth molded	39 feet 6 inches
Depth to promenade deck	24 feet 0 inches



STERN VIEW OF TURBINE STEAMER VIPER ON THE WAYS, SHOWING THE THREE PROPELLERS.

Gross tonnage	1750
Horsepower	6500

She is constructed throughout of mild steel to Lloyd's highest classification for channel service, and to Board of Trade requirements for passenger certificate. In accordance with the most recent developments in passenger steamer design, the accommodation for first class passengers has been arranged forward of amidships, and the second class accommodation is aft.

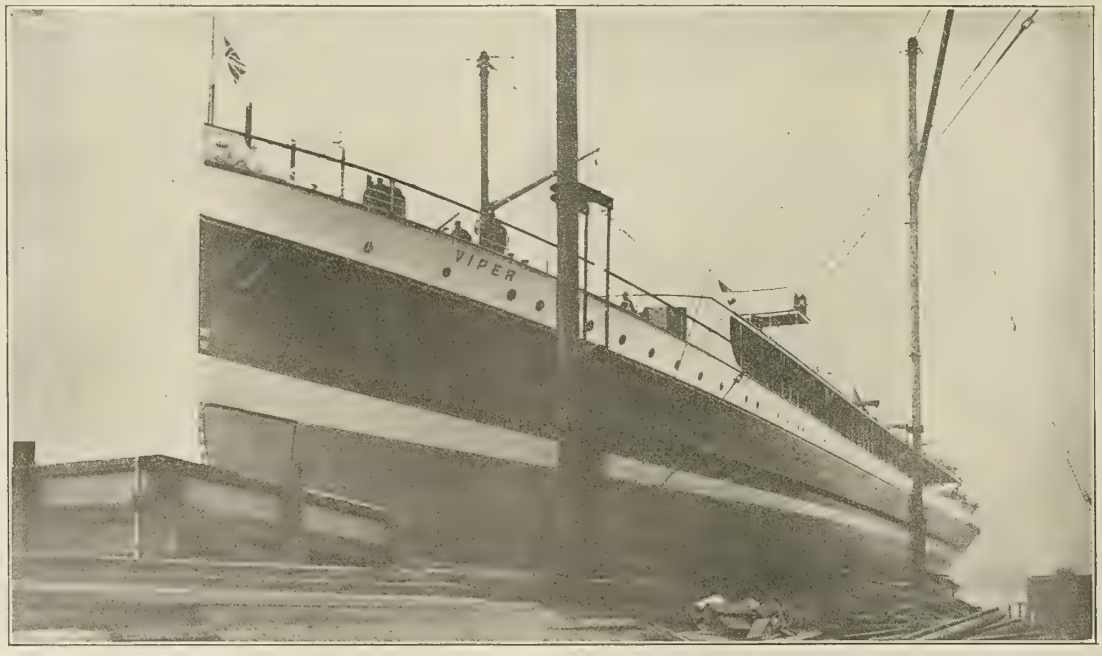
On the promenade deck are the entrance halls, the first class smoking room, tea room and state rooms. On the main deck forward is the first class main saloon and first class ladies' cabin, while aft on the same deck is the second class main saloon, also the crew's quarters. On the lower deck are the dining saloons; that for first class passengers is 78 feet long and has seats at tables for 125 diners, while the second class saloon aft has seats for 105 diners. The vessel will be steered by a balanced rudder aft, and in addition she has a bow rudder for use in navigating the narrow harbor at Ardrossan.

The propelling machinery consists of three independent Parsons compound steam turbines and two condensers. There are

two low pressure turbines and one high pressure turbine, each driving a separate shaft with one three-bladed propeller on each shaft.

The condensing water is circulated through the condensers by two large centrifugal pumps. The engine room will be fitted with all modern appliances, including a large feed filter and suitable feed heater.

Steam will be supplied by four double-ended boilers of the ordinary multitubular marine type, fitted with Howden's forced draught. The turbines and other machinery have been constructed by the Fairfield Company. With the low pressure turbines are incorporated the reversing turbines, with which the vessel, when going full speed, can be stopped in one minute and a half.



THE VIPER ON THE WAYS, JUST PREVIOUS TO BEING LAUNCHED.

TRIALS.

The trials of the *Viper* on the Clyde deserve some notice here. This vessel has a straight stem, a tumble home stern, long upper promenade deck with steel shelters forward, two light pole masts and two funnels. She carries 1,700 passengers.

The series of trials were carried through without a hitch. They consisted of preliminary spins, a series of runs on the measured mile at Skelmorlie at uniformly progressive speeds, six double runs between the Cloch lighthouse and Cumbrae lighthouses at full speed, a stopping trial from full speed, and three runs backwards at full speed on the measured mile. On all these trials the *Viper* was loaded with coal and pig iron, so as to represent as nearly as possible her actual service condition, and the results aimed at were largely exceeded. A speed of over twenty-two knots was reached and the contract speed of twenty-one knots was obtained with natural draught only, although ½ inch air pressure was allowed by the contract. The run from Ardrossan to Belfast will therefore be done in about 3½ hours.

From full speed ahead the vessel was brought to a dead stop in one and a half minutes. A speed of 14½ knots astern was recorded, without forcing the astern turbines to their full power. Anchor and electric light trials were also successfully carried out.

B. T.

The Dry Dock Dewey reached her destination in Olongapo Bay, Philippine Islands, on July 10th.

Engineers in the Navy.

In the course of his remarks upon a paper by Fleet Engineer W. J. Harding, R. N., entitled "The Defense of the Realm," Lieutenant Carlyon Bellairs, R. N., M. P., had occasion to refer to the present attempt to make naval officers "Jacks-of-all-trades." He said, in part:

The moment we had one profession including both engineering and seamanship we had this trouble—that, having entered the service with the idea a boy had of becoming a Nelson, that idea would remain with him all his time, and when he was down on the engine-room platform he would have both eyes on the bridge, instead of devoting his attention to that great and noble profession of engineering, as he should do. We have seen that occur in the American navy. Before 1900 the Americans started the business of one officer doing all the jobs. One of the heads of the engineering profession last year reported that the result has been this—that the American navy was unfit to go to war! That was a very serious statement for the head of the engineering profession to make, but it seemed to be borne out by what occurred in the American warship *Bennington*. That disaster disclosed an extraordinary state of affairs. There was a young officer, a direct product of that system of learning seamanship, gunnery, and engineering all in one, in charge of the engines. He did not bother about the safety-valve being tested. When the ship got up steam a man was told to shut an air-cock. He closed a cock which shut the pressure-gauge off one of the boilers. That pressure-gauge continued to register zero, although the pressure-gauge on another boiler was accounting for another pressure. Stoking went on, and by-and-by that boiler burst, which resulted in the other boiler bursting as well, and there was a most appalling loss of life on board. The casualty was all the outcome of the attempt to create a "Jack-of-all-Trades"—a "handy Billy"—who was a man of no trade at all.

The Fast Motor Boat Brooke I.

Our photograph gives an idea of the general appearance of a recent production of J. W. Brooke & Company, Limited, Lowestoft, England, the boat being 39 feet 9 inches long and 5 feet 6 inches wide. She is fitted with a double mahogany skin built diagonally and very smooth.

The engine, which has six cylinders, measures 10 inches bore by 8-inch stroke, and operates a 6-throw crank shaft, 3¼ inches

in diameter, and forged solid from nickel-steel. The cylinders are bolted to a cast steel crank chamber, made in two parts, and the power (350 horsepower) is transmitted to the propeller shaft by means of a double ring expanding clutch 12 inches in diameter. The thrust is taken up by means of a Hoffman ball thrust block. Ignition is by means of a low tension magneto machine. The propeller has a diameter of 22 inches, and runs at 900 revolutions per minute.

BROOKE I.

In spite of considerable difficulty with the carbureter fitted, the boat has been speeded up to 26 knots, and it is anticipated that with the difficulty removed a maximum speed of 31 knots will be possible.

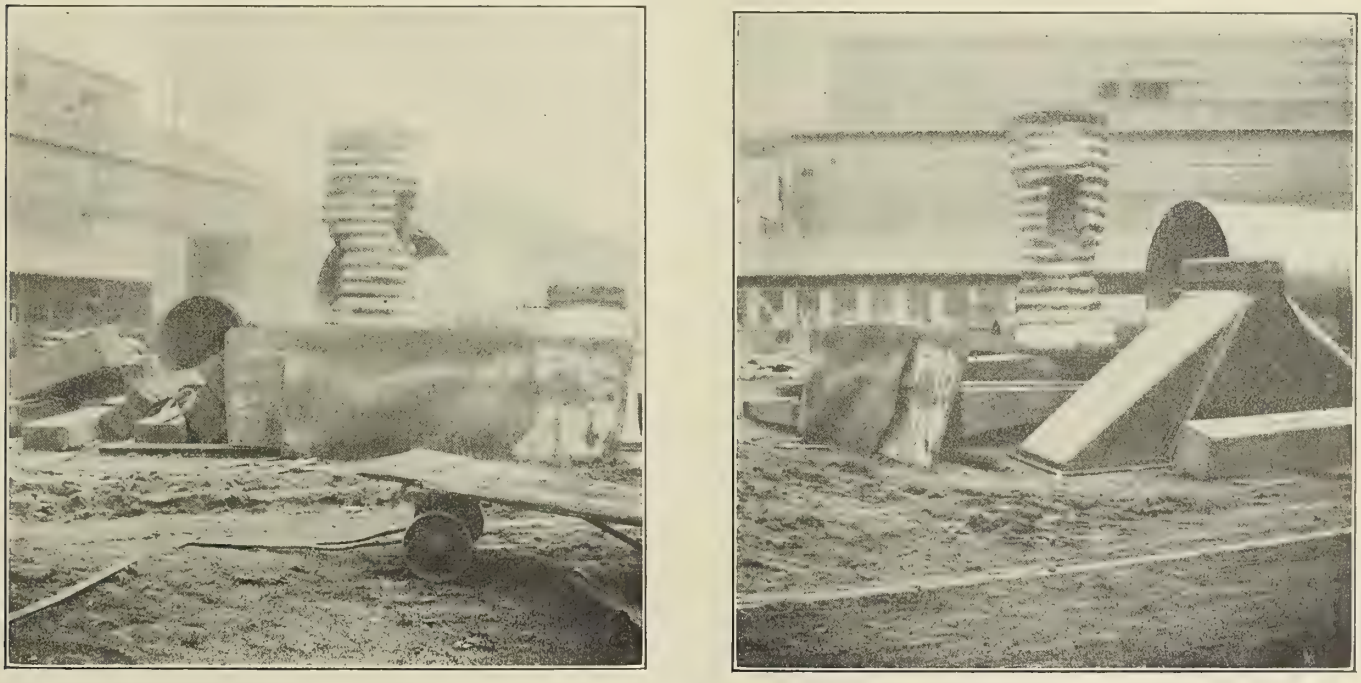
Flue Collapse on the Steamship Acme.

With only one Scotch boiler to furnish steam for her engine, the steamship *Acme* was recently in a very perilous position in stormy weather on the Pacific, near San Francisco harbor. The furnace on the port side of the boiler opened a crack, which made it necessary to draw fires and thereby, of course, stop the engines and the progress of the vessel.

The accompanying illustrations show the damaged flue, which was removed from the boiler for the purpose of putting in a new one. On examination of the boiler flues, scale more than ½ inch in thickness was found, which readily accounts for the disaster, although the steam pressure was at the relatively low figure of 100 pounds per square inch. The boiler was fitted for oil burning, and the flues have a diameter of 40 inches.

A CLOSER VIEW OF THE FLUE.

The three hollows forced into the weakened flue are of very considerable size, one of them having been 17 inches wide and 30 inches long, with a depth of 14 inches and a crack ½ inch by 3 inches across the bottom; another, 18 by 40 inches and 15½ inches deep; and the third 24 by 30 inches and 15¼ inches deep. These came in such positions as to stop up the flue passage to such an extent that an ordinary sized man would have had difficulty in crawling through to the combustion chamber.



TWO VIEWS OF THE DAMAGED FLUE, AFTER ITS REMOVAL FROM THE BOILER.

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The Speed Supremacy of the Atlantic.

On June 28 began what has been universally considered to be a race between two of the most prominent of the high speed liners covering the passage of the North Atlantic. The result of this race was almost a foregone conclusion because of the fact that the *Deutschland,* of the Hamburg-American Line, with its quadruple expansion engines of an aggregate of 37,000 indicated horsepower, holds the time record for the fastest passage across the Atlantic; although another German ship, the *Kaiser Wilhelm II* of the North German Lloyd Line, has made a slightly longer passage at a slightly higher rate of speed. The other contestant in the race was the new French Line flyer *La Provence*, fitted with four-cylinder triple expansion engines which developed on trial a little over 30,000 horsepower.

The best transatlantic passage of the *Deutschland* was made at a higher rate of speed than the trial trip of *La Provence,* and the German ship, having a higher freeboard forward, is much better capable of battling with heavy weather than is her French rival. On the other hand, the French ship was on her third return passage across the Atlantic, and her bottom was presumably in very good condition as compared with that of the *Deutschland,* which had not been in dock for many months, and was probably pretty foul.

The contest for the best Atlantic speed began long before the days of steam propulsion, and will persist long after steam has been supplanted by the next motive element in point of historical order. The only very definite information which can be obtained upon the subject at the present time, however, is concerned with the contest as among the numerous steam-propelled ships which have been in the service during the past sixty or seventy years. It is only within the last twenty-five years that a passage has been made at a rate of speed higher than 19 knots, the present highest record being a trifle more than 23½ knots. The first ship to cross in less than six days made her record-breaking passage as recently as 1889, and it is only within the last six years that any ship has covered the trip at a rate of as much as 23 knots. The end, so far as present indications go, and referring solely to ships propelled by steam, is not apparent, for the Cunard Line has just launched two ships destined to take from the Germans, for the time being at least, the honor of maintaining upon the service the fastest ships afloat. It is rumored that one of the German lines is about to undertake the construction of a ship which shall exceed in both size and speed the new Cunarders. The rivalry is very keen, particularly when, as in the particular case under consideration, it assumes an international aspect.

Ineffective Armored Cruisers.

In another column we are publishing an extended description of the trial trip of the new United States armored cruiser *St. Louis,* which has been turned out by the Neafie and Levy Ship and Engine Building Company of Philadelphia. This vessel and her sister ships are carried on the navy lists as protected cruisers, simply because the act of Congress authorizing their construction used that term. The ships were made much more powerful than was contemplated in the original act, and are in every sense of the word armored cruisers, although they are far from the highest type of such vessels.

It is natural, in considering the military qualities of a ship, to compare it with ships of about the same size and character, as they exist, either in effect or in design, in other navies. The ship in question is of almost the identical displacement of a series of ten ships in the British navy, five of which were members of the fleet which visited the port of New York last November. Not only is the size the same, but the main battery consists in each case of fourteen 6-inch

rapid fire guns. This great similarity in size and battery power lends itself readily to a comparison of the ships as a whole, and it is seen at once that the American design is decidedly inferior to the British, in spite of the fact that the British ships were some of them in the water before the American drawings were completed. In the first place, the English ships have a speed of at least one knot better than their American contemporaries, and in some instances the difference is much greater than this. This excess speed is attained, not at the expense of other qualities but simply and solely as the result of better design; for the horsepower developed in the two cases is about the same, and the superiority of the English vessel means very superior hull lines and more efficient propellers.

A still more striking comparison of the new American ships with those of another power is afforded by six of the armored cruisers of the Japanese navy, of which four were built in England and one each in France and Germany. These ships are of almost the same displacement as the American and English ships above mentioned, and the average speed is about that of the American ships. It is in battery power, however, that the Japanese show their immense superiority. All six carry four 8-inch guns in addition to the 6-inch battery. In two cases there are fourteen 6-inch guns mounted, this being the same number as on the English and American ships, while the other four Japanese vessels carry each twelve 6-inch guns. It is thus seen that each Japanese cruiser has a battery superior by four 8-inch guns, to offset which four of them lack two of the 6-inch size. The superiority in gun power is certainly not less than 50 percent, and, with increasing ranges of action, it is much more than this.

Not only are the Japanese ships more powerfully armed than the American, but they are also more effectively protected against the gun-fire of an opponent. Each of the ships has a belt 7 inches thick, and extending for about two-thirds of the length, as compared with which the American ships have only four inches of armor.

We have no doubt that as a construction, as a typical example of shipbuilding of a particular character, the *St. Louis* ranks very high. As a type of warship to be imitated, however, the design can scarcely be recommended.

Bids for New Battleships.

Bids were opened in the Navy Department June 23 for the construction of the battleships *Michigan* and *South Carolina,* and it was found that two classes of proposals had been made, the first covering simply the design as prepared by the Navy Department, while the other was the design of the builder, the latter in ten cases out of twelve calling for the installment of turbine machinery. A schedule of the various bids follows:

Bidders.	Dept. Plans.	Builder's Plans.
Wm. Cramp & Sons	$3,540,000.†	$4,100,000.
New York Shipbldg. Co.	3,585,000.†	3,900,000.*
		3,850,000.*
Union Iron Works	4,250,000.	
Newport News Co.	3,673,000.	3,813,000.
		3,713,000.*
		3,753,000.*
		3,963,000.*
Fore River Shipbldg. Co.		3,689,000.*
		3,719,000.*
		3,780,000.*
		3,820,000.*
		3,945,000.*

*Turbine machinery.
†Accepted.

The new ships are designed to be 450 feet long, with an extreme beam of 80 feet 2⅝ inches. The load draft at trial displacement of 16,000 tons is 24 feet 6 inches. The total bunker capacity is 2,200 tons of coal.

The battery consists of eight 12-inch rifles mounted in pairs in four turrets all on the center line, as illustrated by sketch diagram on page 255 of our issue for July. The secondary battery includes twenty-two 3-inch rapid fire guns; two 3-pounder and eight 1-pounder semiautomatic guns; four machine guns; two field pieces and two submerged torpedo tubes.

Armor protection is furnished by a water line belt of a width of 8 feet, and varying in thickness from 8 to 12 inches. Behind this belt will be a complete girdle of cellulose packing, designed to close up upon exposure to water admitted through a shot hole.

The department's design calls for propelling machinery of the four-cylinder triple expansion type, operating twin screws, and giving the ship a speed of 18 knots with 16,500 horsepower. The steam pressure in the high-pressure valve chest will be 265 pounds. Twelve water tube boilers in three separate water tight compartments are to have an aggregate of 1,050 square feet of grate surface and 46,750 square feet of heating surface, 10 percent of the latter being in the superheater; the ratio is 44.5 to 1. The working pressure is to be 295 pounds per square inch. The three funnels will reach 100 feet above the base line.

These ships represent the answer which the United States has made to the design of the *Dreadnought.* The broadside fire is the same; the forward fire, less; the after fire, greater. The speed is two knots less, accounted for by 2,500 tons less displacement. In spite of the considerably higher cost of ship-building in the United States, it is probable that each of these ships will cost less than will the English monster.

ABSTRACT FROM RULES AND REGULATIONS OF BUREAU VERITAS.

EDITION OF 1905.

ARRANGED BY HARRISON S. TAFT.

PART IV.

22. Shell Plating.

1. The midship scantling is to extend for ½ the length amidships. Forward and aft of said ½ length the plates may be gradually reduced in thickness as per table 6.

2. Shell plates are to be not less than 6 frame spaces in length. The difference in thickness between adjoining plates of the same strakes must not exceed $\frac{1}{16}$ inch. The thickness at the ends of the garboard strakes and of the strakes of bottom plating adjoining same shall not be more than $\frac{1}{16}$ inch less than the midship thickness of said respective strakes.

3. Boss plates on single screw steamers and the aftermost plates of the strakes below them must be of the same weight as their respective strakes amidships. Likewise all furnaced plates at bow and stern. The thickness of the two aftermost plates of the shell strakes from the boss plates to top of the propeller frame must not be more than $\frac{1}{16}$ inch less than the midship thickness of the corresponding strakes.

4. With the machinery fitted aft, no reduction from midship weight will be allowed in the shell plating aft up to the counter.

5. Outside strakes are to have solid liners of the same breadth as the frame flange, fitted in one length between the plating and the frames. Bulkhead liners are to extend from the frame before to the frame abaft the bulkhead: or else efficient diamond plates are to be fitted.

6. Butts of the garboard strakes are to be well shifted from each other and from the keel scarphs. Those of adjoining strakes of the shell plating (also of stringer and deck plating) are to have at least a two frame space shift from each other. Two butts of the shell plating in the same frame space must not come oftener than on every third strake.

7. Compensation must be made for all doors, side ports or other openings cut in the shell plating. As far as possible it is best not to make any holes in the sheerstrakes.

8. When a continuous double bottom is fitted with the plates of same worked fore and aft, the shell plating (except the keel and garboards) entirely within said bottom space can be of reduced thickness. reductions must stop at a suitable distance from the ends of said bottom.

9. Bulwark plates are to be of the same weight as those of the upper part of hold bulkheads.

10. For vessels navigating in ice the bow plating from the stem to two frames abaft the forward collision bulkhead, between the light load water line and two feet above the deep load line, must be in thickness 1½ times the thickness of the midship plating, but it need not exceed one inch. Aft of this increased thickness the plating may gradually be reduced to regular thickness, but the difference between two adjoining plates of the same strake must not exceed ⅛ inch.

11. The main sheerstrake is to be worked at the upper deck in one, two and three deck vessels, but at both the spar and second decks in spar deck vessels.

12. See also sections 34, 35 and 36 for awning deck vessels, raised deck vessels, poops, forecastles and bridgehouses respectively.

TABLE 6.—THICKNESS OF SHELL PLATING AT ENDS.

(Beyond the ½-Length Amidships)

Thickness of Shell Plating for ½-Length Amidships.	32nds	Quarter Length	32nds	Thickness of Shell Plating for ½-Length Amidships.
	7	7-32nds	7	
	8	8-32 "	8	
	9	8-32 "	9	
	10	9-32 "	10	
	11	9-32 "	11	
	12	10-32 "	12	
	13	11-32 "	13	
	14	12-32 "	14	
	15	13-32 "	15	
	16	14-32 "	16	
	17	14-32 "	17	
	18	15-32 "	18	
	19	15-32 "	19	
		First Eighth / Second Eighth		
	20	16-32nds / 18-32nds	20	
	21	17-32 " / 19-32 "	21	
	22	17-32 " / 20-32 "	22	
	23	18-32 " / 21-32 "	23	
		First Twelfth / Second Twelfth / Third Twelfth		
	24		24	
	25	18-32nds / 20-32nds / 22-32nds	25	
	26	18-32 " / 21-32 " / 23-32 "	26	
	27	19-32 " / 22-32 " / 24-32 "	27	
	28	19-32 " / 23-32 " / 25-32 "	28	
	29	20-32 " / 24-32 " / 26-32 "	29	
	and Above	4-32 less than midship plates / 3-32 less than midship plates / 2-32 less than midship plates	and Above	

23. Butt Straps.

1. In general the butt straps of the sheerstrakes are to be worked in one length. In case the sheerstrakes extend above the gunwale bar sufficiently to allow of two horizontal rows of rivets above said bar the butt

straps can be fitted in two pieces, the part above the gunwale bar being $\frac{1}{16}$ inch thicker than if the strap had been worked in one piece.

2. With double butt straps, the one that is calked is to be in thickness 70 percent of that given in table 9, the other strap being 60 percent.

3. All butt straps of the masts, and yards and other spars are to be $\frac{1}{16}$ inch thicker than the plates they connect.

4. Butt straps are to be fitted to the butts of all doubling plates. Also to the butts of all continuous angle bar keelsons or stringers.

5. When butt straps are fitted to floor plates, center plate keels and keelsons, they are to be worked double.

6. Care must be taken to get a proper shift of the butts of all adjacent members.

7. All butts of keelsons, bilge and hold stringer angle bars or bulbs, are to have scarph pieces at least 2 feet long. Bulb angles may be have a lap equal to at least $2\frac{1}{2}$ times the depth of the bulb, in lieu of strap or scarph pieces.

8. If an outside shell strake is butted in way of a bulkhead liner, a butt strap must be fitted to said butt in addition to the liner, but it can be in thickness $\frac{2}{3}$ of what it ordinarily would be.

24. Riveting.

1. The thicker of two plates is to regulate the diameter and system of riveting used. The greatest thickness of the shell plating is to regulate the size of rivets used to secure the frames and reverse frames to said plating.

2. The system of riveting used in the longitudinal seams amidships is to be carried all fore and aft.

3. The longitudinal seams of the shell plating are to be chain riveted.

4. The riveting of butts of shell plates over 58 inches wide shall be specially considered.

5. In steam vessels with machinery placed aft the shell butts shall be treble or quadruple riveted at the after end if the same be required amidships.

6. When treble riveted butts are used amidships in screw steamers, the three after most butts in each of the shell strakes from the keel up to at least the deep load line are also to be treble riveted.

7. The riveting of doubling plate butt straps is to be the same as for other butts. They should be well riveted on their edges with extra rivets in the frames.

8. The keel plates and garboard strakes are to be connected to the stern frame by three rows of rivets when the thickness of these strakes respectively are $\frac{11}{16}$ and $\frac{5}{8}$ inch: Also in high speed steamers. Tap rivets are recommended for one of the rows.

9. There are to be three rivets in each flange on each side of the butt of the scarph pieces to frames at center line.

10. Scarphs pieces to butts of reverse frames; to butts of floors and bilge keelsons; and to those of hold stringers are to have three rivets in each flange on each side of the butt.

11. Reverse lugs on frames and top of floors are to have at least a three rivet connection to same.

12. When the upper deck gunwale bar is 4 inches by 4 inches and over, double riveting (zigzag fashion) is to be used in both flanges.

13. Rudder rivets should not exceed one inch in diameter.

14. Rivet holes are to be punched from the faying surfaces.

15. Countersinking to extend at least through $\frac{2}{3}$ of the thickness of shell and stringer plates.

16. The Following to be Single Riveted:

a. Longitudinal seams of plated decks.

b. Longitudinal seams of the tank top plating, including those of the center line and margin strakes when said strakes are under 15-32 inch thick.

c. Butts of deck plating at ends of ship where of or under $\frac{5}{16}$ inch thick.

d. Butts of the tank top plating outside of machinery space where of or under 11-32 inches thick.

e. Bulwark butts where of or under $\frac{1}{4}$ inch thick.

f. Seams of lower masts, bowsprits and polemasts when built with angle bar stiffeners.

g. Seams of topmasts and yards.

17. The Following to be Double Riveted:

a. The inner edge of the deck stringer plate in vessels of 400 feet or more in length.

b. Longitudinal seams of the bottom plating to upper turn of the bilge if said plating is or over 11-32 inch thick.

c. All longitudinal seams of the shell plating (including spar and awning decks top sides) if the side plating is or over $\frac{7}{16}$ inch thick.

d. Longitudinal seams of the sheerstrake and of a flat plate keel are to be double riveted when the adjoining plating is or over 11-32 inch thick.

e. Longitudinal seams of the tank top center line strake and of the margin plates whenever said strakes of plates are or over 15-32 inch thick.

f. Butts of floor plates with double strap.

g. Web frames to floors.

h. Side plated rudders.

i. Seams of lower masts built without angle bar stiffeners.

j. Seams of polemasts built without angle bar stiffeners to be double riveted to above lower mast hounds.

k. Butts of all spars (except as indicated under trebleriveted).

18. The Following to be Treble Riveted:

a. Butts of the first side plates in poops and raised quarter decks as well as those at the ends of bridgehouses.

b. Lapped butts of floor plates (three complete rows).

c. Butts of lower masts, top-masts, bowsprits (outside of wedging) and polemasts.

d. Butts of fore and main yards for the ¼ middle length.

TABLE 7.—RIVETING SCHEDULE. LAPPED AND STRAPPED BUTTS.

Thickness in inches of Keel Plates; Garboards; Bilges; Upper, Main, Spar and Awning Deck Sheerstrakes, Stringers and Deck Plating; All top sides plating above the main deck; Bridge Plating.		Style of Riveting ½-Length Amidships Lapped or Butted Straps	Style of Butt Straps
Iron Rivets	Steel Rivets		
Under 13/32	Under 14/32	Double	Single
of 13/32 " 19/32	of 14/32 " 21/32	Treble	Single
of 19/32 " 24/32	of 21/32 " 28/32	Quadruple	Single
of and Over 24/32	of and Over 28/32	Treble	Double

Sides and Bottom of the Shell Plating

In application of the above thickness to Side and Bottom Plating the thickness of same is to be reckoned as follows:

Amidships		At Ends	
Iron Rivets	Steel Rivets	Iron Rivets	Steel Rivets
80% of the actual midship thickness	90% of the actual midship thickness	65% of the actual midship thickness	75% of the actual midship thickness

25. Double Bottoms.

1. The center line keelson must have a double angle bar connection to the tank top plating. Said keelson must be stiffened by bracket plates at each frame where no solid or bracket floor is worked.

2. Side longitudinals worked continuously throughout the double bottom space, and spaced not more than 4 feet apart, are to be located on each side of the center line, being secured to the shell and tank top plating by a single angle bar.

3. The tank top margin plates are to be secured to the shell plating by a longitudinal angle bar worked continuously, the frames being cut at said point.

4. The frames outside of the margin plates are to be secured to same by bracket plates of the same thickness as the flange of the frame. Inside of the margin plates those frames which have no solid or bracket floors fitted to them are to have a bracket plate connection to the margin plates. The brackets are to have a depth at the bilge equal to at least twice the depth of midship floors at center line.

5. Vessels of 22 and under 29 feet in depth are to have every fourth tank top frame bracket secured to the margin plates by double angle clips. Those of 29 feet or over in depth are to have every second bracket thus connected to the margin plates. All fore and aft in both cases. In single decked vessels every fourth frame is to be thus secured with depths ranging from 19 to 25 feet and every second bracket for depth of 26 feet and above. All web frames are to have double angle clips to said margin plates; but gusset plates may be fitted in lieu of said clips.

6. Floors cut at the center line girder are to have a double clip connection to same, when the width of said floors is more than ⅗ that of the midship floors and the vessel's beam exceeds 42 feet. When the beam is between 36 and 42 feet the clips are to be worked single and double alternately. In the machinery space and coal bunkers they are to be worked double throughout.

7. Double Bottoms with Floors on Alternate Frames.

a. When this type of construction is adopted bracket or solid manhole floor plates must be fitted intercostally between the continuous side longitudinals on alternate frames. Said floor plates must be of the same thickness as said longitudinals.

b. When the longitudinal number exceeds 450,000 solid manhole floor plates must be fitted in all cases.

c. In the engine room solid manhole floor plates must be fitted to every frame; in the boiler room to alternate frames; bracket floors not being allowed in either space.

d. With this type of construction floors must be fitted to every frame for 15 percent of the vessel's length abaft the fore peak bulkhead.

8. Deep Floor Plates on Every Frame.

a. Said floor plates are to extend in one piece from the center line to the margin plates.

b. A side longitudinal is to be worked intercostally betweeen said floor plates, midway between the center line and margin strake on each side of the vessel; said longitudinal plates being 1/16 inch thicker than the floor plates.

c. Two such longitudinals are to be fitted if the vessel's beam at the tank top exceeds 34 feet.

d. Auxiliary longitudinal girders must be fitted in way of the machinery to suit condition of same.

e. Solid manhole floors are to be fitted throughout the machinery space as stated above (25-7-*c*).

f. This system of construction is recommended for vessels in which the center stanchions are omitted.

9. Longitudinal Girders on Top of Ordinary Floors.

a. Said longitudinal girders must not be spaced more than 4 feet apart or from the center line girder. The

side girders may be ⅛ less in thickness than the center line girder. They are to have a continuous angle bar on their upper and lower edges for securing said girders to the reverse bars on top of floors and to the inner bottom plating. The center line girder is to have a double top and bottom angle connection to the reverse bars on top of floors and to the inner bottom plating.

b. Bracket plates are to be worked so as to give sufficient athwartship strength to said double bottom.

c. The floor and lower bilge keelsons may be dispensed with in this type of construction.

d. If the double bottom does not extend the entire length of the vessel the center girder on top of floors must scarph the center line keelson, and the floor and bilge keelsons must extend for at least three frame spaces into said double bottom in order to maintain continuity of strength.

10. When a double bottom is worked under the boilers and engines, the floors under the boiler bearers and engine seating must be ⅛ thicker than otherwise. The tank top plating in the engine and boiler rooms, and in the cross-bunkers is to be of increased thickness.

11. When the bed plate of the engine rests directly on the tank top plating the thickness of the tank top plating under said bed plate must be twice that of the regular engine room tank top plating. The holding down bolts of the bed plate are to be tapped into the heavier plating, with nuts, washes and grummets worked on the underside.

12. When a double bottom extends through the machinery space the second floor from the after end of the engine compartment should be made solid and watertight so as to provide for a drainage well at said point. Means should be provided for thorough draining the top of the inner bottom plating.

13. Proper manholes are to be cut in all side longitudinals and between each side longitudinal in all solid floors so as to allow of free access to all parts of the double bottom. Those in the side longitudinals are to be well shifted from each other and from all butts of the tank top and longitudinal plating. The size of the manholes are to be such as to leave a clear plate surface all around equal to at least 2½ times the depth of the vertical flange of the frame angles. Those in the tank top plating should be at least 12 inches x 18 inches in the clear.

14. There should be at least 12 inches between the boilers and the tank top plating.

15. All boiler and engine foundations and all other foundations should be securely riveted to the main part of the vessel. Under no conditions will bolts be allowed.

16. Double bottoms should be divided by a sufficient number of watertight floors so as to provide stability in filling or emptying the tanks.

17. Double bottoms are to be tested before launching by a head of water equal at least to the deep load draft of the vessel. In no case shall the head of water be less than 8 feet above the crown of the tanks. All peaks are to be similarly tested.

18. Water Ballast Holds or Deep Tanks. In deep water ballast tanks it is recommended to adopt a center line longitudinal bulkhead well stiffened and well secured to the bounding bulkheads of said tanks.

26. Hatches and Deck Openings.

1. The coamings of hatchways on exposed decks are to stand at least 18 inches above the deck planking. The coaming of hatches on the decks below the weather deck need not exceed 12 inches in height. In vessels with a low freeboard, the coamings of upper deck hatches are recommended to be made at least 30 inches deep.

2. If a coaming is of or over 24 inches in height above the deck, or is of or over 16 feet in length, it is to be stiffened or made heavier than otherwise.

3. All hatch coamings must extend to the bottom of the beams. When the beams are fitted on alternate frames the coamings are to be secured to said beams by double clips.

4. Shifting beams, spaced not over 8 feet apart, are to be fitted to all deck openings when the length of said opening exceeds 12 feet.

5. One fore-and-after is to be fitted to all cargo hatchways. When said hatchways exceed 10 feet in width, two fore-and-afters are to be fitted for supporting the hatch covers.

6. When the length of a hatchway exceeds six feet, it is recommended to fit a web frame in the hold in way of the stanchion under the mid length of the fore and aft carling.

7. Hatchways over ⅓ the vessel's beam in width call for special consideration.

8. Engine and Boiler Room Hatchways and Casing.

a. Engine room skylights and boiler castings are to have their coaming plates stand at least 30 inches above the deck. On the upper decks of awning deck vessels, and on poops and bridgehouses, the height of said coaming may be but 18 inches.

b. The casing of the engine and boiler room hatchways is to extend from the second to the upper deck. The bottom of any door way in said casing must be at least 18 inches above the deck.

c. When the length of the engine and boiler room hatchways exceeds 7 frame spaces, the upper and second decks must be strengthened as stated in section 18, paragraph 1-*g*, for hatchways over 9 frame spaces in length.

27. Masts, Spars and Rigging.

1. Lower Masts.

a. The length of a mast for determining its scantlings is to be measured from the top of the upper deck beams (second deck in awning deck vessels) to the hounds.

b. When a lower mast is of 44 feet or more in length measured as above stated it must have angle stiffeners extending its whole length. At least 3 rows of stiffeners must be fitted if the mast is made of 2 or 3 strakes of plates, and 4 rows if four strakes are used. In no case need the thickness of said stiffener angles exceed the thickness of the mast plating at the partners.

c. Doubling plates 5 feet long are to be fitted at the wedging deck, and similar plates 1 foot long at the heel.

d. Lowermast check-plates are to be ⅓ inch thicker than mast plates at partners. Their fore edge is to be strengthened by an angle bar or otherwise; their upper edge by an angle bar worked around the mast.

2. Topmasts.

a. The length for regulating the scantling of the topmast is to be measured from the lower mast cap to the top mast hounds.

b. When said length is over 21 feet in square rigged masts two rows of stiffening angles must be fitted the whole length of said top masts. The flange width of said angle bars is to be ⅓ of the diameter at the top mast's heel, their thickness being the same as the plating at said point.

c. Doubling plates at least 2 feet long are to be fitted in way of the lower mast cap. Fid and sheave holes are to be strengthened by doubling plates at said points.

3. Polemast.

a When the lower and topmasts are made in one piece the length for determining its scantlings is to be taken as stated above for lower masts.

b. If the length of a pole mast from upper deck beams (second deck in awning deck vessels) to topmasts hounds exceeds 44 feet three rows of angle bar stiffeners should be fitted. When angle stiffeners are fitted to the lower part of a polemast they must extend up to the topmast head.

c. The diameter of a polemast at truss hoops shall not be less than the greatest diameter of the yard located at said hoop.

4. Yards.

a. The total length of a yard (excluding the arms) is to regulate its scantling.

b. When a yard is over 20 inches in diameter it is best to strengthen same by one row of angle bar stiffeners to each strake of plating in the round.

c. The plating is to be worked double at the truss hoops.

5. Bowsprits.

a. When built to take a flying jibboom the length for regulating the scantling of a bowsprit is to be taken from gammoning to the cap. When the bowsprit and jibboom are made in one piece or length, said length is to be measured from the gammoning to the end of the jibboom.

b. The bowsprit shall be strengthened by a vertical web plate connected by four angles to the bowsprit plating.

c. Doubling plates are to be fitted at the gammoning.

(To be continued.)

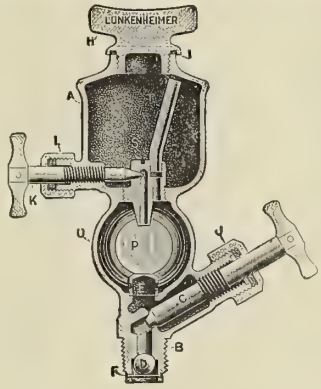
ENGINEERING SPECIALTIES.

The Premier Gas Engine Lubricator.

For the lubrication of gas or gasoline engine cylinders, the Lunkenheimer Company, of Cincinnati, O., has recently placed on the market a new device, illustrated herewith. The cup is made entirely of bronze composition; the construction is very compact, and the general design will appeal to users. The cup was constructed not only with a view to positive and proper lubrication, but also to readily withstand severe service. The filling hole is large, which users will appreciate, especially when the cups are applied to motor boat engines, as it permits the use of a filling can having a large spout. To positively insure a tight joint between the filling plug H, and top of cup, the cup is provided with a lead washer I, which material, being softer than the brass upon which it bears, will readily conform to any irregularity that might exist between these bearing surfaces.

The regulation of the feed is accomplished by means of the valve K, provided with a fine needle point, and the thread on the stem being also of fine pitch, a close adjustment can be obtained. The stuffing box L, not only serves the purpose of preventing leakage around the stem valve, but brings the proper amount of friction to bear on the stem, and thereby prevents the unsetting of the valve.

To provide against the back pressure interfering with the proper formation of the drops in the sight-feed, and causing the oil to spatter around the glass, the shank B is fitted with a large ball check valve D. It has been found, however, that where the back pressure is unusually great, as in engines with worn piston rings, the ball check does not entirely remedy the trouble. To meet this condition, a baffling cap E, has been provided just above the valve C. The gases escaping past the ball check D are effectually muffled and diffused by means of the cap E, and hence the drops form perfectly, drop freely and steadily, and the sight-feed glasses never fill up. Another feature is the construc-



tion of the sight-feed. This consists of the holder, retaining ring, two rubber washers, and the "bull'seye," made of a superior grade of glass, and very thick.

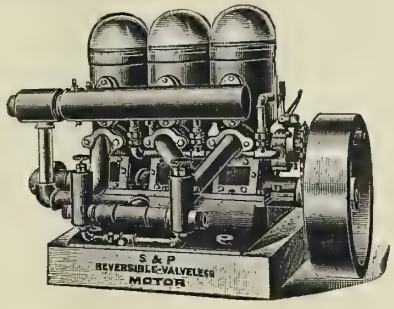
A Reversible Valveless Marine Motor.

A two-cycle engine with jump spark ignition, and of comparatively light weight, has been placed upon the market by Sittmann & Pitt, 213th street and Harlem river, New York. The water jacket around the cylinder being carried completely down to the crank chamber, insures a cool crank case on a long run, which means more power, as a greater volume of gas is then taken in and carried to the cylinder. The water enters at the bottom of the water jacket, and is carried completely around the cylinder and up into the head, then into the water jacket of the exhaust pipe, and a portion is allowed to enter the exhaust

pipe, forming a spray which further cools the exhaust gases, thus not only removing the back pressure but also most of the noise and odor as well.

The duplex pump supplies the water jacket of the engine and takes care of the bilge water.

The timer is of a new design, and makes a full and positive contact with a very rapid break, being especially adapted for a non-vibrating coil. In place of cams, hardened steel rollers of ample diameter are used to operate the vertical studs, which at their upper ends are set with platinum, no current being carried through the friction wheels.

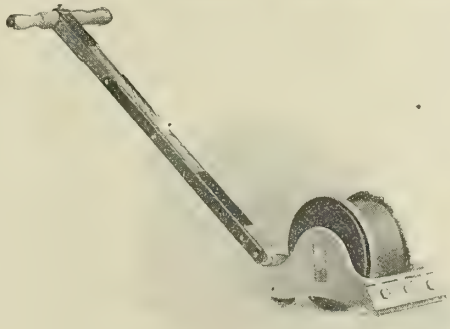


With the reversing lever, which is combined with the timing lever, the need of a reversing propeller is done away with, and a solid wheel of a true and correct pitch can thus be used. The engine runs in either direction. It is so easily started that it can almost be called a self-starting engine, a quarter turn of the fly wheel being all that is required on the double cylinder 10 horsepower. The hoods or caps on the heads of cylinders thoroughly protect them from short circuiting in rain or spray. Salt water fittings are used throughout.

The engines are built in single, double, triple and quadruple cylinders, representing 5, 10, 15 and 20 horsepower, respectively, and measure only 16½ inches high from center of shaft to top of cylinder head. Over all length on double cylinder 10 horsepower is 25 inches, including fly wheel, and weight is 340 pounds.

The Little Giant Floor Scraper.

Among the latest inventions placed on the market, which is of interest to all shipbuilders, as well as contractors and architects, is a machine for scraping and surfacing hardwood floors. This is an expensive, slow and laborious operation when done by hand, as it has always been done in the past, and in most cases unsatisfactory in results. A machine which saves time,



labor and money, while producing far superior work, leaving the floors smooth and even, without marks of any kind, is the "Little Giant" floor scraper, shown in the accompanying cut.

It is used successfully on any hardwood flooring, including oak, maple, birch, beech, yellow pine and parquet. No portion of the floor is beyond its reach, as it works right up to the base-board, and into all corners. High joints are quickly cut down, and the floor is left smooth and free from any marks of the knife. The machine is operated by one man, without additional motive power, and will do from three to six times as much work in a given time as the old hand method.

By the use of additional attachments, which are furnished by the manufacturers of the machine, the Hurley Machine Company, 153 South Jefferson Street, Chicago, floors are sandpapered and polished to perfection. For old floors there is another attachment, the use of which solves the vexing problem of redressing old worn floors. This removes all old varnish and filler, and puts the floor in prime condition, doing away with staining, liquid varnish removers or other substitutes which have been offered ineffectually for this work. The construction of the machine is said to be simplicity itself.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 350.—I have a pair of 7 by 28 inch stern-wheel plain piston valve engines with links, and an oil burning locomotive marine boiler of 350 feet heating surface, allowed 200 pounds steam working pressure in a 100 by 20 foot hull, draft 14 inches. The stern wheel is 11 feet 6 inches outside diameter by 12 feet. The engines, at ¾ stroke cutoff, turn up 30 to 31 revolutions. The slip is about 17 percent. The boiler makes sufficient steam to keep the pressure at 190 pounds to 200 pounds and feed water at about 180 degrees.

What would be the probable theoretical increase of power and speed and revolution with the same boiler and a pair of 8 inches by 42 inches automatic cutoff engines working at ¼ stroke cutoff, and the wheel increased to 12 feet outside diameter by 12 feet. Would the new take more or less steam?

The engine exhaust is into the feed water heater, and passing thence into the smoke stack.

A.—With your pair of 8 by 42-inch engines and cutoff at one-quarter stroke the probable increase in power per revolution with the same steam pressure and disposition of the exhaust would be some 25 to 30 percent. This should result in an increase of 10 to 12 percent in revolutions with the same wheel, and in a practically equal percentage increase in speed, and in a total increase of power developed of some 30 to 35 percent. At the same time, the steam required from the boiler would remain about the same, or might undergo a slight reduction.

With the larger wheel, about the same total increase in power and in speed would be realized, but at revolutions remaining nearly the same, or perhaps decreased by 4 or 5 percent.

So far as the relative amounts of steam required can be figured directly from the volumes of the two cylinders up to the point of cut-off and the revolutions per minute, it appears that the larger engine with earlier cutoff and increased revolutions would require some 20 percent less *volume* of steam than with the present arrangement. Such an apparent saving in steam must however be discounted by the increased effect due to cylinder condensation with the earlier cutoff, the exact amount of such loss depending on the various circumstances of the case, and admitting of only rough estimate with the information in hand. It is probable, however, that such loss would be less than 20 percent, and that there might result a total steam consumption less than at present by perhaps as much as 10 percent. On the other hand, if it is desired to drive the boilers as at present, and to use as much steam as with the present arrangement, then it is probable that the preceding figures for speed and total power developed may be bettered by one or two points. To such end, of course, the cutoff will be carried a little later than one-quarter stroke, and up to a point where the entire output of the boiler is worked off.

Q. 351.—Will you kindly inform me what is meant by suspending the link forward of the link arc, also what is the usual amount of angular advance given eccentrics on large and small engines? What are the

advantages and disadvantages of an eccentric with 100 degrees angular advance in comparison with an eccentric with 130 degrees angular advance? L. S. R.

A.—The link of a Stephenson valve gear is hung or connected to so-called side or bridle rods for the purpose of controlling its movements in reversing, linking up, etc. The point of attachment of these rods to the link may be either on the center line of the link arc drawn through the center of the link block, or at some point inside or outside of such center line. The effect of a change in the location of this point is to produce a change in the amount and character of the block-slip, or relative motion between the block and the link during the revolution. This in turn will have its influence on the character of the steam distribution, and by appropriate use of this influence the valve events and general character of the steam distribution may be made somewhat better equalized in the two ends of the cylinder than they would otherwise be. Whenever the point of attachment is thus located off the center line of the link arc, it is either for structural reasons and in disregard of the influence of such location on the character of the steam distribution, or it is to produce some desired influence on such distribution by the utilization of the modifying influence of the block slip as noted above.

A full discussion of these points will be found in our columns for June and July, 1905.

The purpose of a change in the angular advance of an eccentric is to produce a corresponding change in the timing of the various valve events relative to the position of the piston. Thus, with other things equal, a valve with 130 degrees angular advance instead of 100 degrees will open to steam earlier and have more lead, will cut off earlier, will open to exhaust earlier, and will close exhaust or begin compression earlier. Of course, the relation between the events on the admission and exhaust sides may be modified by changing the relative amounts of lap on the valve; but in general, a change in angular advance changes the time of the valve events relative to the positions of the piston.

The amount of angular advance varies widely according to the details of the steam distribution desired. The usual range may be put from 120 to 140 degrees, but there is no one figure which can be named as the "usual" value.

A full discussion of these points will be found in our columns for November, 1903.

TECHNICAL PUBLICATIONS.

Transactions of the Society of Naval Architects and Marine Engineers, Vol. 13, 1905. Edited by William J. Baxter, Secretary of the Society. Size, 8¼ by 11 inches. Pages, 395; plates, 201. New York, 1906. Published by the Society. Price, $10.

This consists of the eighteen papers and the discussions on same, read at the thirteenth annual convention of the Society, November 16 and 17, 1905. These papers were all outlined in our issue for December, 1905, and the gist of the discussions was there given. Several of the papers have been published in full in our columns.

Transactions of the American Society of Mechanical Engineers, Vol. 26, 1905. Edited by Professor F. R. Hutton, Secretary of the Society. Size, 6 by 9 inches. Pages, 841; figures, 292. New York, 1905. Published by the Society. Price $10, paper covers; $11, bound.

This includes the proceedings of the fiftieth and fifty-first meetings of the Society held respectively in New York and Scranton, and covers thirty-nine technical papers along the lines covered by the practice of the membership of the Society.

Information Guide for Transatlantic Travelers, 4th Edition. Size, 4 by 8½ inches. Pages, 108; illustrations, 20. New York, 1906. The Frank Presbrey Company.

This little paper-bound volume, which can be readily carried in a coat pocket, gives a large amount of condensed information on subjects in which the ocean traveler is naturally interested. It contains maps of the principal harbors of Europe and the eastern coast of the United States, as well as a map of the North Atlantic ocean. There are given particulars of the principal ships of the leading transatlantic lines.

Water Softening and Treatment, By William H. Booth, A. S. C. E. Size, 5½ by 8½ inches. Pages, 308; figures, 102. New York, 1906. D. Van Nostrand Company. Price, $2.50 net.

The treatment of water for steam boiler and manufacturing purposes forms a question of great importance to the user of the steam or water, the main object being of course to reduce the amount of hard scale deposited in the boiler or the fabric. The subject is taken up in this book in five sections, of which the first and largest deals with the treatment of water by softening, together with the subjects of oil separation and filtration. The other four sections deal with mechanical methods of treating water, and with the apparatus required for such purposes. Of course the first section is largely a question of chemistry, and of the several forms of devices used in chemical softening. This part of the work, as well as that devoted more specifically to the mechanical method of caring for the water, is thoroughly illustrated, mostly by line cuts covering English and continental practice.

Under the mechanical head are taken up the subjects of heat, condensers, air pumps, circulating pumps, feed water heating, auxiliaries, water cooling by atmospheric evaporation, feed pumps, injectors, etc., and a number of tables are introduced giving the properties of the various substances used, as well as factors of evaporation, tables of solubility, and tables showing sizes and capacities of the various types of apparatus.

Things that Are Usually Wrong, By John E. Sweet. Size, 5¼ by 7½ inches. Pages, 52; figures, 50. New York, 1906. Hill Publishing Company. Price 50 cents.

Professor Sweet takes up a variety of devices in which in his extensive practice he had found errors in the usual method of handling the propositions under consideration. These errors are in the line of misconceptions of underlying mechanical principles, and relate to a great variety of items in connection with both steam engines and machine tools, including such auxiliary devices as pulleys, shaft hangers, etc. The aim of the book is, of course, to correct anything of the sort, by pointing out the defects of prevailing practice in such a way as to call attention to both the discrepancies and the proper remedy therefor. It is thus constructive as well as destructive in character, and is well worth careful perusal.

The Barritt-Serviss Star and Planet Finder. Collaborated by Leon Barritt and Garrett P. Serviss. Size, 15 by 15 inches, with pamphlet 9¼ by 6 inches. New York, 1906. Leon Barritt. Price $5.

This device consists of a chart of the heavens with all of the important fixed stars and constellations in proper position, the chart being arranged to rotate in such manner as to bring successively into view through an opening the portion of the solar system visible in the Northern Hemisphere, at any hour of the day or night, and for any day of the year. It is so arranged that the time of rising and setting of any of the stars can be ascertained sufficiently closely for ordinary purposes, while the positions of the planets, including the sun and moon, are set, by means of thumb tacks, upon the ecliptic from directions given in the pamphlet in such a way as to show clearly the time and setting of each one of the positions which it occupies among the constellations. The pamphlet gives tables covering the years from 1906 to 1925.

Beeson's Marine Directory of the North Western Lakes. Size, 6¾ by 9½ inches. Pages, 271; illustrations, 40. Chicago, 1906. Harvey C. Beeson, publisher, 251 Dearborn street. Price $5.

The present volume is the twentieth which has appeared, and is very similar to the last few numbers of this work, but is, of course, brought up to date in all respects. It contains a complete directory of all the steam vessels and sailing vessels on the

Lakes, including both American and Canadian craft, while under separate headings are the iron ore carriers, lumber vessels and particulars of boilers and machinery of the steam vessels on the Lakes. Statistics are given of the commerce through the Soo canals, and notes covering the transportation and steamboat lines. The illustrations are mostly half tones, and represent subjects of a wide variety of character, including passenger and freight steamers, steam and sailing yachts, marine machinery, lake, river, coastwise and ocean-going vessels, and a number of craft long since out of date, and interesting merely from the historical point of view. A map showing the new location of the New York State canal system is put in as a folder.

PERSONAL.

Chief Engineer John Quincy Walton of the Revenue Cutter Service has been nominated by the President as a constructor, so that his services may be at all times at the command of the service in connection with the design of new steamers, etc.

George I. Rockwood has been appointed Professor of Steam Engineering of the Worcester Polytechnic Institute, Worcester, Mass.

Charles E. Hyde, of Bath, Maine, has become president and general manager of the new organization of the New London (Conn.) Marine Iron Works. The new company has taken over the property of the old Morgan Iron Works, and, with additions contemplated, will have a complete plant for the repairing and outfitting of all classes of vessels.

Arthur W. Goodrich has been transferred from the Department of Construction and Repair in the Mare Island (Cal.) navy yard to the Department of Steam Engineering in the same yard, his capacity being that of draftsman.

Made in Germany.

At the time when the Hamburg-American steamer *Kaiserin Auguste Victoria* reached New York harbor on her maiden trip, there were in the harbor at that one time the largest steamship in the world, (the *Kaiserin*), which was built in Germany; the fastest steamship in the world, (the *Deutschland*, of the same line), which was built in Germany; and the largest sailing ship in the world, (the *Rickmers*), which was built in Germany; the This combination furnishes food for thought to Americans interested in shipping.

Shipbuilding in the United States.

The Bureau of Navigation of the Department of Commerce and Labor reports that during the fiscal year ending June 30, 1906, there were built in the United States a total of 1,079 sail and steam vessels aggregating 348,345 gross tons, as compared with 1,054 of 263,064 gross tons during the preceding year. In addition to this, there were built 384 unrigged vessels, such as barges, etc., of 73,399 tons, as compared with 247 in the preceding year, of 63,149 tons. The entire increase for the year is more than accounted for by larger construction on the Great Lakes, the figures being 239,448 tons in the present year, as compared with 103,550 in the preceding year. The falling off on the Atlantic and Pacific coasts aggregates 49,302 tons, or more than 30 percent.

The steel vessels propelled by steam amounted in the present year to 109 of 281,741 gross tons, as compared with 73 of 159,355 gross tons. In the present year nearly one-half in number and 84.4 percent in tonnage represent construction on the Lakes. There seems to be a decided falling off in the construction of wooden vessels propelled by sails, the tonnage having dropped from 72,730 to 33,327.

On the seaboard only two steamers for foreign trade have been built during the year, these being the *Mexico* and *Merida*, of 6,207 tons each, under mail contract for service to Cuba and Mexico, and built to replace two steamers sold to the Government for service to the Isthmus of Panama. Aside from these two only one ocean steamer of upwards of 1,000 tons was constructed.

The annual report of the Liverpool Steamship Owners' Association, for the year ending December 31, 1905, shows that the members of the Association owned at the end of the year a total of 3,524,426 gross tons of steam shipping, the net tonnage being 2,202,547 tons, and the number of vessels 857. The gross tonnage is stated to represent 21 percent of the total British steam tonnage afloat; 36 percent of the total number of steam vessels afloat having a speed of 12 knots and upwards; and 43 percent of the total number of steam vessels afloat of above 5,000 tons each. The average size of the vessels included is 2,570 tons net and 4,113 tons gross.

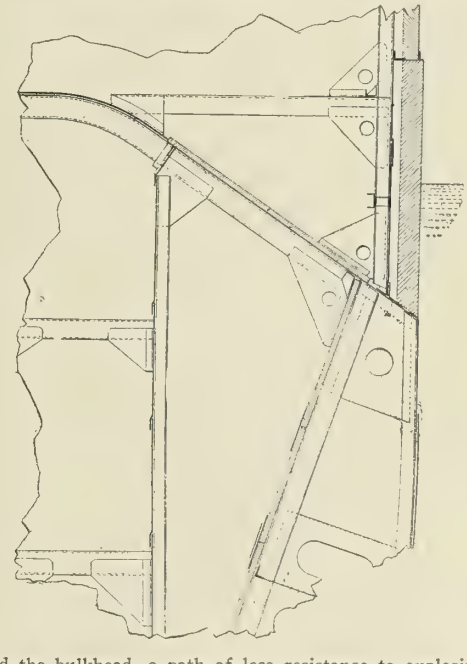
The statistical records given in the report show an almost steady increase in tonnage owned by the members of the Association, there being only three years since 1868 when the gross tonnage is smaller than at any previous year. In the year last mentioned, the tonnage was 310,669. It first passed the million mark in 1883, with 1,005,650 tons. The two-million mark was first passed in 1900, when the tonnage was 2,221,824; and the three-million mark in 1904, with 3,237,891 gross tons.

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

817,227. ANTITORPEDO CONSTRUCTION FOR WAR VESSELS. WILLIAM A. DOBSON, PHILADELPHIA, PENNSYLVANIA.

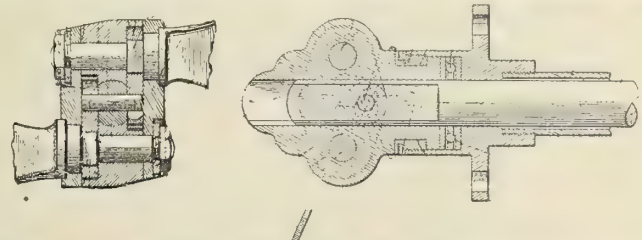
Claim.—2. In a device of the character described, a downwardly and inwardly extending armored bulkhead and an exterior hull forming, be-



tween it and the bulkhead, a path of less resistance to explosives than that of the bulkhead, the direction of which path is external to the main plane of the bulkhead. Thirteen claims.

817,728. REVERSIBLE PROPELLER-WHEEL. FRANK M. SPAULDING, ST. JOSEPH, MICH., ASSIGNOR TO WILLIAM H. HULL, ST. JOSEPH, MICH.

Claim.—3. The combination of a rotary but axially-stationary hub,



blades adjustably mounted on said hub, the stems of said blades being

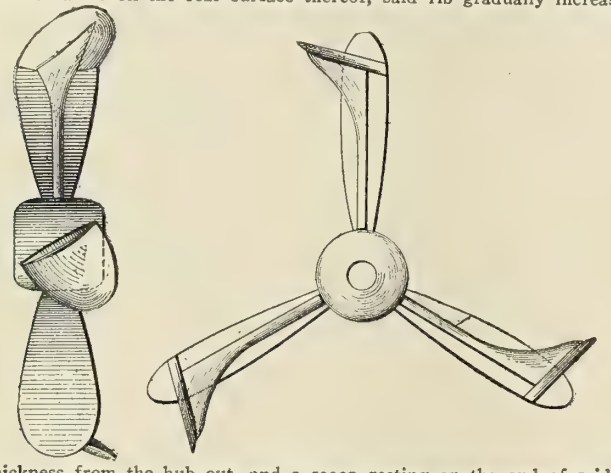
provided with crank-arms and each crank-arm having a longitudinally-extending slot; an endwise-adjustable shaft provided with a pin engaging and working in said slots and adapted to rotate said hub and slide longitudinally therein; a bearing in which said propeller-wheel shaft is mounted and which sustains the thrust of the propeller-wheel; an engine-shaft having a telescoping connection with the end of said propeller-wheel shaft; and manually-operated means for shifting said propeller-wheel shaft endwise for the purpose of reversing the said blades. Ten claims.

817,262. GOVERNOR FOR MARINE ENGINES. JAMES W. MOWBRAY, WALTON, CANADA.

Abstract.—The object of the invention is to devise a simple, cheap, positive, and effectual governor to prevent the engine racing due to the lifting of the propelling-wheel out of the water in high seas; and it consists, essentially, of a stand-pipe extending through the bottom of the boat in proximity to the stern, a cylindrical casing secured to the upper end thereof, a piston located in such casing and having a piston-rod connected thereto and extending through the upper end of the casing, a supplemental piston connected to the upper end of the piston-rod, a supplemental cylinder suitably supported above the main cylinder and in which the supplemental piston works, and a lever suitably pivoted at one end and connected to the piston-rod, and means connecting the free end of the lever with the butter-fly throttle-valve on the steam-pipe of the engine. Four claims.

817,494. PROPELLER-WHEEL. ALBERT HENRY LITTLE, NEW YORK.

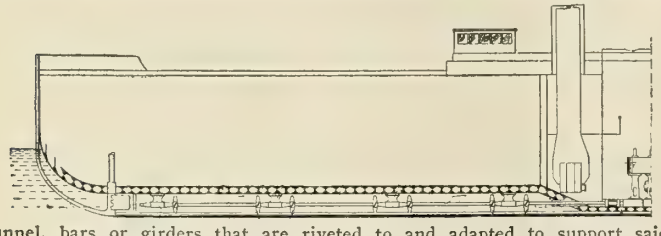
Claim.—3. A propeller-wheel having a series of blades, each being provided with a rib on the rear surface thereof, said rib gradually increasing



in thickness from the hub out, and a scoop resting on the end of said rib and near the end of the blade. Five claims.

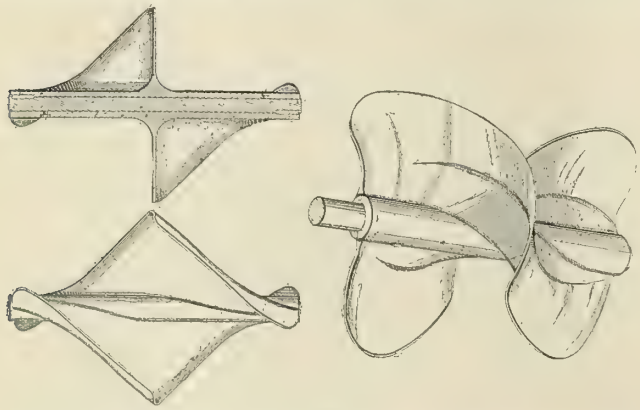
817,519. VESSEL PROPELLED BY STEAM. ERNEST C. ROBINSON, WEST HARTLEPOOL, ENGLAND.

Claim.—8. A navigable vessel comprising a tunnel that extends from end to end of the lower part of said vessel and is furnished with a bottom consisting of metal plates wherein throughout the entire length of the tunnel, openings are provided; extending throughout the entire length of said



tunnel, bars or girders that are riveted to and adapted to support said plates; at each end of said vessel a stem-post or frame that extends to the bottom of said tunnel and has formed in it an opening adjacent to the corresponding mouth of said tunnel; and rudders mounted within said openings in the frame or stem-post and inwardly turned toward the mid-ship section of said vessel. Ten claims.

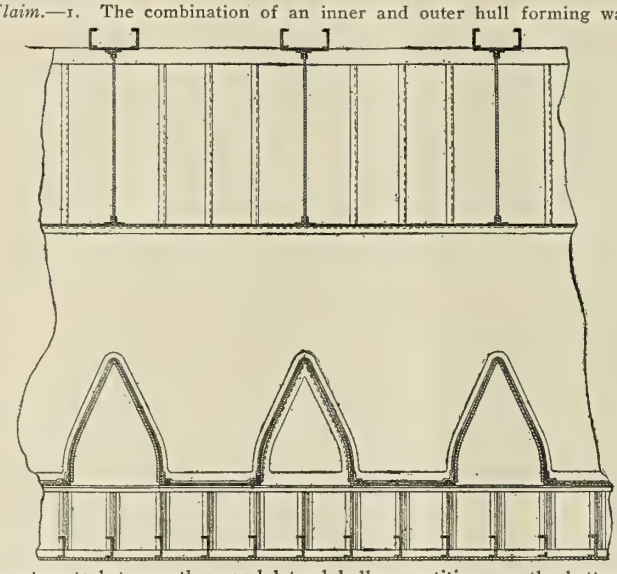
818,125. PROPELLER. ROBERT W. SHAW, STAMFORD, CONN., ASSIGNOR TO THE SHAW PROPULSION COMPANY, A CORPORATION OF NEW YORK.



Claim.—5. The herein-described propeller having blades throughout its length, said blades having curved flanges and being spirally disposed with substantially one half thereof (measured longitudinally) in an intersecting spiral plane relative to the body portion of the propeller whereby but one of said halves will act upon the water to propel a vessel when the propeller is positively driven, and the other half will act upon the water to propel a vessel when reversely driven. Seven claims.

818,259. SHIP CONSTRUCTION. JOSEPH KIDD, DULUTH, MINNESOTA.

Claim.—1. The combination of an inner and outer hull forming water-



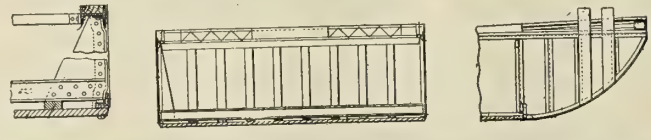
compartments between them and lateral hollow partitions on the bottom of the inner hull communicating with the water-compartments and forming a series of lateral hoppers for the bulk cargo. Four claims.

818,778. FIRE-BOAT. LEWIS NIXON, NEW YORK.

Claim.—3. In a fire-boat, the combination of a gas-engine, a pump, a clutch connection with said gas-engine, a centrally-located rigidly mounted main nozzle, and automatic means for throwing and distributing water from said pump to cool the decks. Four claims.

819,633. BARGE. ARTHUR M. BOWMAN, AVALON, PA.

Claim.—3. In a barge, the combination of sides composed of a skeleton girder-framework having upper and lower longitudinal flanged elements, intervening stud members having inner and outer parallel flanges, with



side plates secured thereon, cross-connecting bracing elements, and a floor composed of wood, sloping upwardly at each end and providing prow extremities, with supplemental prow-plates forming continuations of the bottom and curving upwardly at each end. Thirteen claims.

820,105. ELECTROLYTIC SHIP-BOTTOM CLEANER. GEORGE W. FRAZIER, ALLEGHENY, PENN., ASSIGNOR TO PITTSBURGH ELECTROLYTIC MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

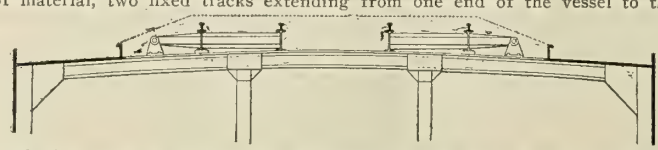
Claim.—1. In an electrolytic ship-bottom cleaner, the combination of a conducting-plate, tackle constructed to suspend said plate from the vessel movably contiguous to the side of the vessel below the water-line, insulating-fenders arranged to prevent contact between said plate and the sheathing or hull of the vessel, a conductor leading aboard from said plate, a source of electricity having one pole connected with said conductor and the remaining pole connected with the sheathing of the vessel. Six claims.

820,974. STEEL BARGE. MEIER G. HILPERT, PITTSBURG, PA.

Abstract.—The invention consists, generally stated, in constructing the barge of a number of separate sections or compartments, each of which preferably is a self-contained unit both as to stability and flotation, and which sections are constructed to be attached one to another, so as to build up the complete barge or fleet, which are constructed of sizes so that when empty a plurality thereof can be nested together, thus reducing the cubical contents and wetted surface and both expediting and rendering more cheap the return of the empty barges, which are of such a size that they can be lifted by suitable hoisting apparatus and unloaded by merely dumping the same, thus greatly expediting and cheapening the unloading thereof, which are of such a size that they can be transported by land as well as by water either on ordinary flat-cars, by telpherage system, or as desired, and which possess many other special features of construction and advantages, as will be hereinafter described and claimed. Fifty claims.

821,514. VESSEL. ALEXANDER LESLIE, WALKERVILLE, CANADA, ASSIGNOR OF ONE HALF TO GEORGE E. TITCOMB, PHILADELPHIA, PA.

Claim.—4. The combination of a vessel having a hold for the storage of material, two fixed tracks extending from one end of the vessel to the



hold, two series of movable tracks pivoted to the deck of the vessel and arranged to either swing over the hold and in alinement with the fixed tracks or to be thrown back clear of hold and out of alinement with the fixed tracks. Five claims.